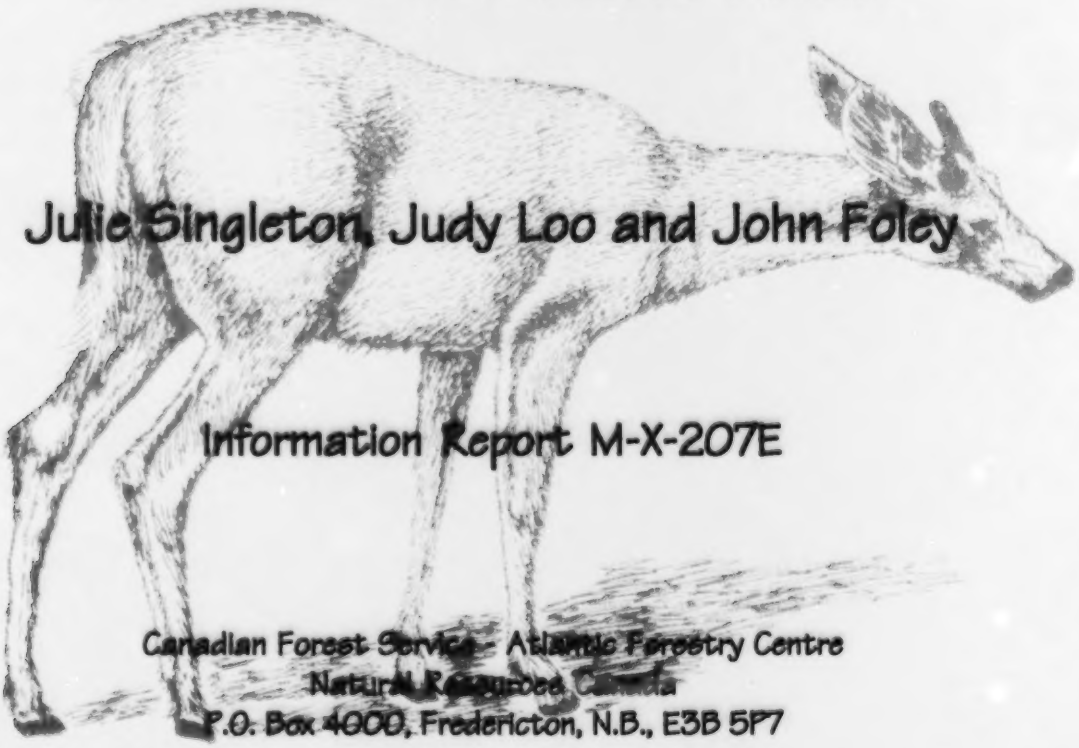
Conservation Guidelines For Ecologically Sensitive Forested Sites On Private Woodlots Within The Fundy Model Forest



Julie Singleton, Judy Loo and John Foley

Information Report M-X-207E

Canadian Forest Service - Atlantic Forestry Centre
Natural Resources Canada
P.O. Box 4000, Fredericton, N.B., E3B 5P7

2000

Canada

CONSERVATION GUIDELINES FOR ECOLOGICALLY SENSITIVE FORESTED SITES ON PRIVATE WOODLOTS WITHIN THE FUNDY MODEL FOREST

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ABSTRACT

This manual provides management guidelines aimed at protecting biodiversity in ecologically sensitive sites found on private woodlots within the 420 000-ha Fundy Model Forest of southeastern New Brunswick. Eight forest community types were identified in the area by a gap-analysis project (MacDougall and Loo, 1996). Each of these community types occupies a relatively small area, in most cases due to past or on-going land use. These eight community types are the focus of management recommendations in this manual, the objective of which is to maintain the existing sites until some degree of restoration takes place on a provincial scale. Many of the suggested management options could be further modified and used over a broader land base to restore forest communities that have been reduced or lost. This manual will be used by technicians working with the Southern New Brunswick (SNB) Wood Cooperative, Department of Natural Resources and Energy staff, private woodlot owners, and others who wish to identify and manage these sites.

RÉSUMÉ

Le présent manuel présente des lignes directrices pour la gestion qui assurent la protection de la biodiversité dans les sites écosensibles situés dans des boisés privés que renferme la forêt modèle de Fundy, une zone de 420 000 ha située dans le sud-est du Nouveau-Brunswick. Huit types de collectivités forestières ont été relevés dans le secteur dans le cadre d'un projet d'analyse des écarts (MacDougall et Loo, 1996). Chacun de ces types de collectivités occupe une superficie relativement faible en raison, dans la plupart des cas, de l'utilisation actuelle ou passée des terres. Ces huit types de collectivités se situent au centre des recommandations en matière de gestion du présent manuel, dont l'objectif est de préserver les sites actuels jusqu'à ce qu'un certain renouvellement se soit produit à l'échelle provinciale. Nombre des options de gestion proposées peuvent être encore modifiées et utilisées sur un territoire plus étendu afin de rétablir les collectivités forestières réduites ou perdues. Le présent manuel s'adresse aux techniciens de la Southern New Brunswick (SNB) Wood Cooperative, au personnel du ministère des Ressources naturelles et de l'Énergie, aux propriétaires de boisés privés et aux autres intervenants qui désirent recenser et gérer ces sites.

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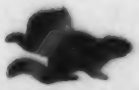

INTRODUCTION

The purpose of this manual is to develop forest management guidelines aimed at protecting biodiversity in ecologically sensitive sites on private woodlots within the Fundy Model Forest (see Figure 1). It is necessary to maintain these existing sites until some degree of restoration takes place on a provincial scale. This manual will be used by technicians working with the Southern New Brunswick (SNB) Wood Cooperative, N.B. Department of Natural Resources and Energy (NBDNRE) staff, woodlot owners, and others who wish to identify and manage these sites.

The criteria to identify ecologically significant areas on forest sites are as follows:

1. Presence of uncommon or rare species, including some of the rare plants listed throughout this manual.
2. Presence of "rare - spatially restricted" assemblages of species, such as wet cedar forest sites, which contain mixes of species not found on other sites.
3. Little-disturbed remnants of once-more-common community types such as mature tolerant hardwood stands or red spruce stands (MacDougall and Loo, 1996).

These criteria apply to a variety of sites in the Fundy Model Forest (FMF) and across the province. Although these areas are important to maintain biodiversity across the landscape, the larger forest community must not be forgotten and must also be managed in an ecologically sustainable manner. Without this step, further loss of biological diversity is inevitable. Most of the suggested management options in this manual could be further modified and used over a broader land base to restore forest communities that have been reduced or lost.

Eight forest community types were identified within the FMF as being ecologically significant because they met one or more of the above-listed criteria. Each of these community types was identified and described in the publication, *Fine-Scale Community Types of the Fundy Model Forest in Southeastern New Brunswick* (MacDougall and Loo, 1996). They will form the basis for this manual and are as follows:

Hemlock Slope Forest Community Type
Pine—Oak Forest Community Type
Talus Slope Hardwood Forest Community Type
Wet Cedar Forest Community Type
Coastal Ravine Red Spruce Forest Community Type
Sugar Maple—White Pine Inland Cove Forest Community Type
Rich Northern Hardwood Forest
- Sugar Maple—White Ash—Ironwood—Beech Community Type
- Silver Maple—American Elm Alluvial Bottomland Community Type

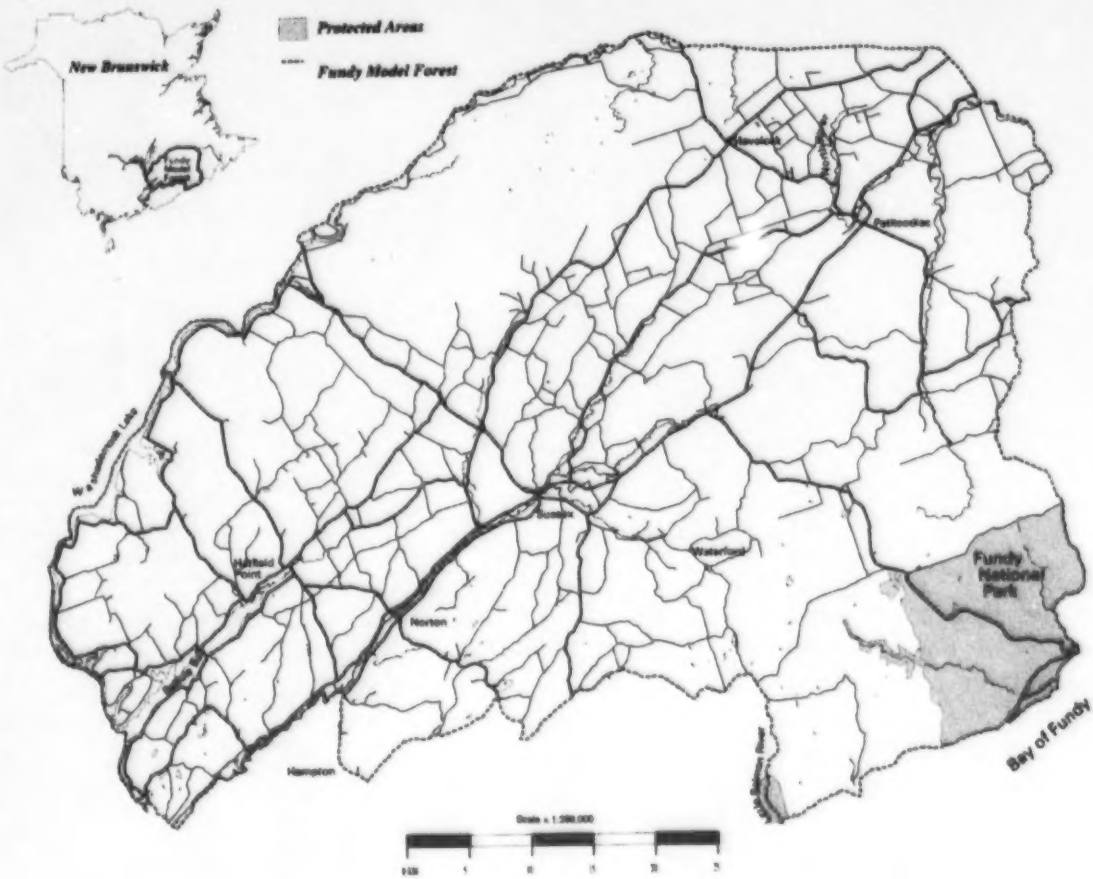

Figure 1. *Map of the Fundy Model Forest in New Brunswick (reprinted from MacDougall and Loo, 1996).*

Biodiversity Loss within the Fundy Model Forest

Several tree species in the Fundy Model Forest, and across the province, have been significantly reduced in abundance and distribution. This decrease in biodiversity may have negative effects on other wild life[1] species that use these trees (Woodley and Forbes, 1997). Research on the abundance of tree species in the Fundy Model Forest during colonial times (175-225 years ago) has identified that the following tree species were once much more common than they are today: eastern white-cedar, ash, eastern hemlock, large, healthy beech, sugar maple, and yellow birch (Lutz, 1997).

Other species such as white pine, red spruce, red oak, ironwood, black cherry, butternut, bur oak, basswood, and American elm have also been reduced over the past century. In fact, most long-lived species, requiring shade for regeneration, have decreased in quantity and quality over the past century or more. Logging pressure or habitat change due to human activity have been the main causes of this loss (Woodley and Forbes, 1997), except for elm and beech which have been reduced in frequency and size by introduced diseases. Because they have decreased in abundance, forest communities containing these species will be the focus of management actions within this manual.

Locating and Protecting Ecologically Sensitive Sites

Although a number of specific ecologically sensitive sites have been identified within the FMF, many more may exist on a much finer scale on private woodlots. SNB staff spend a great deal of time advising woodlot owners on forest management issues. The opportunity exists to increase awareness of these sensitive sites, and to add to the number of known sensitive sites. Proper management may help maintain these community types on the landscape.

Soil maps are the second most important source of information for finding new sites. Forest inventory data are the main source. These maps are available from the FMF office or from the New Brunswick Department of Natural Resources and Energy (NBDNRE) offices, free of charge.

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[1] Wild life is expressed throughout this manual as two words to remind the reader that it refers to all species of plants and animals that are not domesticated.

GENERAL MANAGEMENT RECOMMENDATIONS

The sections that follow contain information on the status of each community type, its habitat and life history, importance to wild life and potential management options. ***The options are hierarchical, so that the best option for ecological conservation is presented first, and an alternative may be listed second. Although the recommendations may appear restrictive, each land manager or owner can modify the guidelines to meet their own needs.*** In most cases, the recommendations focus on ecology, at the expense of economy. Most owners' objectives should be met by the proposed options or a modified version.

Core Management

Figure 2. Sensitive site management layout.

The management site is designed with a central core area (see Figure 2), which is buffered by surrounding forest. The buffer may have modified management activities designed to create habitat for selected uncommon species. ***The most important key to successful management is to carefully select the trees that will remain on site after a harvest and to retain suggested crown closures. In most cases, the trees to be removed should be marked to ensure the best choices remain on site and proper crown closures are maintained.***

Many of the community types discussed in this manual are late successional, shade-tolerant forests that can persist on the landscape, without intervention, for very long periods of time. Even some of the intermediate tree species that require more light for regeneration can survive for centuries. Therefore, interventions in young stands (75-100 years old) are probably not necessary in the short term. Instead these sites should be monitored over time to see if human disturbance is necessary. This will provide an opportunity to try to increase these forest types on the landscape. The ideal situation may be to maintain the core as a gene pool while managing the buffers to allow these target species to establish themselves.

Regeneration, or new seedlings, may not be found under some of these core stands if the crown closure is very dense. This should not be a cause for concern as many of these tree species are very long lived and will eventually establish seedlings once the canopy opens up. In some cases, the stands may be too young to have regeneration. Art Lynds (*pers. comm.*,1998) questions what sufficient regeneration under these stand types really means and feels that fewer seedlings than the current stocking guides recommend may actually be biologically optimal for a site.

There is a great deal of concern as to whether many of the rare plants associated with these sites can survive harvest interventions. Soil compaction, weed invasion following overstorey disturbance,

increased light levels, reduced humidity, and dense vegetation re-growth are the main threats. ***For these reasons, if harvesting is done within the core, a lighter harvest may minimize the impact and protect the site biodiversity. As always, the final decision remains with the woodlot owner.***

The concept of ecosystem management encourages forest management to mimic natural disturbance cycles. On mixedwood Acadian sites, long-term natural disturbance has consisted of gap formation or small, open patches created by age, wind, lightning, and disease or insect infestations. According to Marc-André Villard (1997) the return cycle for fires in Alberta's boreal forest is about 90 years, while in the Acadian forest, it is more in the order of 650-800 years. If we are to mimic nature, efforts should be directed towards small partial cuts with overstorey retention; they should be directed away from clearcutting these forest types. Better yet, allowing these forest types to undergo their natural disturbance regime may retain these declining communities on the landscape.

Although some tree species regenerate better on disturbed mineral soils, this option may eliminate rare or sensitive plants growing on the site. ***Therefore, winter harvests, after soil freeze-up, may be the most effective option to avoid soil damage or disruptions to rare plants within the core.***

Buffer Management

Buffers provide the primary work area needed to increase the numbers of selected tree species and possibly some associated ground plants (see Figure 2). ***The recommended buffer width is usually at least 170 m (500 ft) wide, to reduce edge effects.*** Edge effects include increased light and temperature, decreased humidity, and higher wind speed, thus putting more stress on interior species and allowing more aggressive species to move into the stand. Interior forest species often cannot compete with these aggressors and may eventually be eliminated.

There are many factors affecting edge effects, such as types of trees, direction the cut edge is facing, percent crown closure, prevailing wind direction, and wind speed. Different edge effects are found at variable distances into the stand and may vary from 2—8 km (Noss, 1987; Simberloff, 1993; Matlack, 1994; Hunter, 1990). Matlack (1994) recommends edges greater than 92 m to protect interior forest plants and Hunter (1990) quotes various studies on increased predation of song birds due to edge effects from 100—600 m. After considering all the factors, a buffer width of 170 m was chosen as a workable distance that might protect the selected forest habitat, without removing too much forest land from a woodlot owner's land base.

In some cases a 170-m buffer may not be possible, where 1) the woodlot owner does not wish to set aside this much area; 2) the width of the woodlot may not allow buffers this wide; or 3) the area around the core is not mature forest or does not provide the required crown closure. In these cases, retain a buffer as wide as possible.

Management in the buffer is usually aimed at creating or maintaining optimum light conditions to allow selected species from the core area to expand their position into the buffer. As many of these species prefer shaded sites, maintaining specific crown closures will control the amount of light entering the stand. Through time, with proper site conditions, these species may form a greater part of the forest landscape.

Work in this area can be conducted during times when the ground is not frozen, especially if trying to encourage tree species that prefer scuffed or disturbed mineral soils. Completing work before April 1 and after August 15 will minimize the impact on nesting songbirds.

Restoration

Restoration is one component of conservation stewardship. It means bringing back or increasing proportions of species or community types that have declined. One way to increase rare plants or trees on the landscape is to develop suitable sites where they can be replanted. Little is known about site requirements of ground plants, but more is known about the conditions tree species require.

One method to increase numbers of selected species, is to establish the conditions for regeneration described above under **"Buffer Management."** Another option is to underplant the selected tree species or spread the nuts or seeds on suitable sites, if natural regeneration is not found. This can be done immediately after harvest or the site can be left for up to 5 years to see if regeneration will develop on its own. It depends on the amount of effort and/or expense owners are willing to undertake.

Bruce Matson (*pers. comm.*, 1998) suggested that the criteria for identifying ecologically sensitive sites could include those landscape areas and soils that could support a sensitive community. Many of the tree species that are less common today would have grown in agricultural valleys and their reduction is most likely due to habitat loss. Although it is important to protect existing forest communities containing these species, efforts to restore these communities on sites where they once flourished may be equally important. Although this recommendation is beyond the scope of this manual, it is an important goal to work towards in future protection and management of these community types.

Wild Life

When wild life is discussed, common and rare or threatened species that are known to be associated with a given community type are presented. These descriptions usually include plants, animals, and birds, because information is more readily available than for other groups of species. There is currently minimal information on amphibians, reptiles, insects, mushrooms or mosses and lichens that may be dependent on these forest communities. Other rarities may exist on presently unidentified sites. ***If any of the rare plants identified in this manual are found on site, avoid disturbance if possible until the site can be assessed. One of the people listed under "CONTACT PEOPLE" on page 17 may be able to help.***

Harvest Frequency

Frequency of intervention is another concern that must be addressed by the manager. How often is "too often" to maintain the habitat for wild life species? How far apart is "too far apart" to discourage those who wish to earn a profit from their woodlot? Generally the frequency of interventions can increase as the harvest intensity of each intervention decreases. Thus, single tree selection with a horse or small, light equipment (which causes less soil compaction) can be conducted more fre-

quently than removal of higher volumes with a skidder (which causes more soil compaction). Of course, operator skill is one of the most important aspects of any forest operation, but is most critical when working in sensitive sites.

The ecological answer is to maintain recommended crown closures, which are found under "Management Recommendations" for specific species, and intervene only when crown closures are above these levels. If immediate profits, as opposed to long-term profits, are the driving force, then it may be more difficult to maintain the habitat. Interventions as frequent as every 5 years with a very light touch, or as infrequent as every 30 years if more trees are to be harvested, may be acceptable, provided the recommended crown closures are retained.

Harvest Type

Mature forests are disappearing across the landscape at an alarming rate, leaving fewer potential habitats for species that require forests with old growth characteristics. Selection harvest prescriptions in tolerant forests often advise harvesting at 20-year intervals, removing all dead, dying, diseased, and deformed trees, and always taking the biggest and oldest trees. This treatment quickly renders these stands structurally less diverse than naturally growing stands.

This loss of diversity is caused because there may not be any fallen logs (coarse woody debris) on the forest floor, or snag trees for cavity-nesting birds and mammals or for fungi and mosses to colonize. Sites in northern Maine, where selection harvesting has been practised over several periods, are quite uniform in structure. This means most trees are the same size and age and there are few dead and dying trees left in the stands. This usually results in less species diversity in these managed stands compared with natural sites.

To alleviate these concerns, retain existing cavity trees and some older, deformed trees (sometimes locally called 'wolf trees'); these will provide sites for fungi and cavity nesters, as well as provide the structure complexity of uneven-aged stand conditions (DeGraaf *et al.*, 1992).

Suggested criteria for selection cut sites recommend leaving a minimum of 12—15 standing dead trees >20 cm dbh/ha and 12—15 live or partially dead beech or other species >25 cm dbh/ha (Woodley and Forbes, 1997). Coarse woody debris can be increased or maintained by leaving tree limbs and tops on site after harvest. On all managed sites or stands, there should be a minimum of 200 pieces/ha of coarse woody debris (average piece diameter >10 cm) and a minimum total of 10 m^3/ha at all times (Woodley and Forbes, 1997).

The above standards represent a bare minimum and wherever possible this amount should be increased. Even an additional 50% would be useful. To increase on-site biomass, Jim Drescher (*pers. comm.*, 1998) recommends sawing lumber on site and returning all slabwood and sawdust to the forest. An option for increasing snags and other deadwood is to girdle a few trees that have low economic value but high value as deadwood.

During harvest, it is important to ***retain as many of the late-successional tree species and their associates as possible.*** After harvest, ***underplant late-successional tree seedlings within the buffer or core,*** when sufficient regeneration is not found.

Tolerant trees are best managed by single-tree selection, while intermediates and intolerants can be managed by group selection. Single-tree selection removes trees one by one to maintain a fairly uniform and continuous crown cover appropriate for regenerating shade-tolerant species. Group selection is the removal of groups of trees to create openings from 10-30 m wide to manage species that prefer more light (Leak *et al.*, 1987).

Personal observation, literature reviews, and personal communication with knowledgeable people all indicate that crown closure is the most vital factor in maintaining tree species and their associated wild life. ***If overstorays are too open, rare and uncommon ground plants may be crowded out by weedy regrowth. Therefore, the primary focus within the core must be to retain suggested crown closures by the use of single-tree selection or group selection harvests. Specific guidelines are listed under Management Recommendations for each of the community types.***

Harvest Age

There is a need to revisit the meaning of "mature". According to the provincial Forest Development Survey, mature trees are usually around 80—100 years old, when growth begins to slow down. This generally means trees are big enough to harvest, which we could refer to as "product or economic maturity." For many of our long-lived species, such as white pine or hemlock, the term "mature" may more appropriately refer to 200—300 years old, which we could call "biological maturity." ***Older harvest ages for many of the selected tree species would encourage their survival and propagation, and would produce higher priced products over the long term. When possible, try to allow 25% of the trees in a stand to live for half (or more) of their expected life spans.*** For example, leave 25% of hemlock trees to live to be 200 years old or more, or 25% of red spruce trees to be 150 years old or more. This is a best-guess scenario since there is little or no specific research on this topic. However, research by Seymour (1992) found that less than 5% of 19th Century red spruce trees were under 125 years old, and 72% of all trees were between 150—250 years old. The final 23% of the trees were probably in the 250—400 year range. The average lifespan for red spruce is about 300 years, so stands with at least 25% older trees could provide some old-growth characteristics.

Mature trees are one issue, but mature forests are another. Some species of orchids, such as Calypso, apparently need old-growth cedar stands (greater than 120 years old) for optimum habitat conditions, while numerous species of mosses and lichens may require habitats that have not been disturbed for 200-300 years. Our short-term harvest rotations decimate long-lived tree species and their associated wild life species. ***Therefore, clearcutting should not be done in long-lived, late successional forests, if we wish to maintain them on the landscape in the future.***

Access Roads

Stand access can be a major source of soil compaction, increased edge effect, and light intensity (which may allow weedy plants to displace shade-loving plants). High road and trail density for easier and cheaper harvest often increases the impact. In some stand types, such as wet cedar forests, roads may cause flooding and completely change the habitat type. In rich tolerant hardwood sites, seeps or small wet areas are vital to the survival of many rare species; therefore, road location and construction must be much more carefully executed here than in other areas.

Protection can best be afforded to these sensitive sites, if the main woodlot road is laid out at least 170 m away from the area, but farther if possible. Trails to access the stand should be temporary, as few and as narrow as possible, preferably with a closed canopy. Generally if small equipment is used, and trails used only during winter, ecosystem disturbance may be minimized.

SITE ASSESSMENT INFORMATION AND MAPPING

If a sensitive site is found on a woodlot, the following steps may be taken. The first assessment may be done by an SNB technician. The standard data usually collected during a site visit will suffice for the initial visit to ecologically sensitive sites.

1. Collect standard information including: property identification number, aerial photo number, and site description. Contact people should be notified so they can further assess the site for rare species.

2. Notify contact people to assess the site for rare species and significance of habitat.

3. Mark site location on an aerial photo and ideally on a NBGIC map.

4. If the owner is in agreement, this information will be catalogued in a provincial referencing centre (e.g., Conservation Data Centre) to help determine how widespread these sites actually are (see Kate Bredin under *"CONTACT PEOPLE" on page 17*). If the number of sites declines over the long term, our management efforts are failing; if they increase, we are on the right track.

5. If an owner wishes to provide long-term protection, the Nature Conservancy of Canada or the NB Nature Trust may be able to help (see Appendix and *"CONTACT PEOPLE", p. 17*).

CONTACT PEOPLE

If a site containing rare or uncommon species is found, the following people can be contacted for advice on further assessment:

Judy Loo	Canadian Forest Service - Atlantic Forestry Centre PO Box 4000, Fredericton, NB E3B 5P7 Phone: (506) 452-3398
John Foley	Nature Conservancy of Canada - Atlantic Regional Office 924 Prospect Street, Suite 2, Fredericton, NB E3B 2T9 Phone: (506) 450-6010; fax: (506) 450-6013
Gart Bishop	B&B Botanical 16 Pitt St., Sussex, N.B. E4E 1J1 Phone: (506) 433-4994
Kate Bredin	Atlantic Canada Conservation Data Centre PO Box 6227, 17 Waterfowl Lane, Sackville, NB E4L 1G6 Phone: (506) 364-5034
Hal Hinds	University of New Brunswick Herbarium PO Box 4400, Fredericton, NB E3B 5A3 Phone: work (506) 453-3583; home (506) 455-6467
Margo Sheppard	Nature Trust of New Brunswick Inc. PO Box 603, Station A, Fredericton, NB E3B 4Y9 Phone: (506) 457-2398; fax: (506) 450-2137

MANAGEMENT RECOMMENDATIONS FOR COMMUNITY TYPES

Hemlock Slope Forest Community Type

Hemlock was once quite common in New Brunswick, as evidenced by the following quote, written over a century ago, *"In New Brunswick, [hemlock] forms a large proportion of the evergreen forests, and is found abundantly multiplied in every favorable situation"* (Perley, 1847).

Today the amount of hemlock is steadily declining throughout its range, because of current unsustainable harvesting practices (Godman and Lancaster, 1990). Both the amount of forest area containing hemlock and the volume are continuing to decline because of harvesting and failure to regenerate (Godman and Lancaster, 1990). Two NB studies also show hemlock to have declined in the province (Lutz, 1997; Zelazny and Veen, 1997).

Hemlock slope forests are uncommon within the Fundy Model Forest, occurring in small localized patches in only a few locations in the Fundy Highlands from Sussex to Elgin. These stands do not contain large trees. Because of its limited distribution and possible vulnerability to human disturbance, hemlock may require specific management actions to ensure its long-term persistence in the FMF (MacDougall and Loo, 1996). At present, nine hemlock stands, all small in size, have been identified within the FMF (Woodley and Forbes, 1997).

Porcupine eat hemlock and may kill mature trees, while heavy deer browsing on hemlock seedlings can eliminate regeneration. Under normal circumstances, these losses would probably not be a serious threat but, because of the limited number of hemlock stands, there is more cause for concern.

Importance to Wild Life

Hemlock slope forest understorey vegetation is sparse because of the dense shade. Common ground plants include partridgeberry, creeping snowberry, bunchberry, wild lily-of-the-valley, pink pyrola, wood sorrel, and twinflower. Occasionally, the large round-leaved orchis has been observed in hemlock understoreys. This species is rare and may not be a good competitor in community types with denser understorey vegetation.

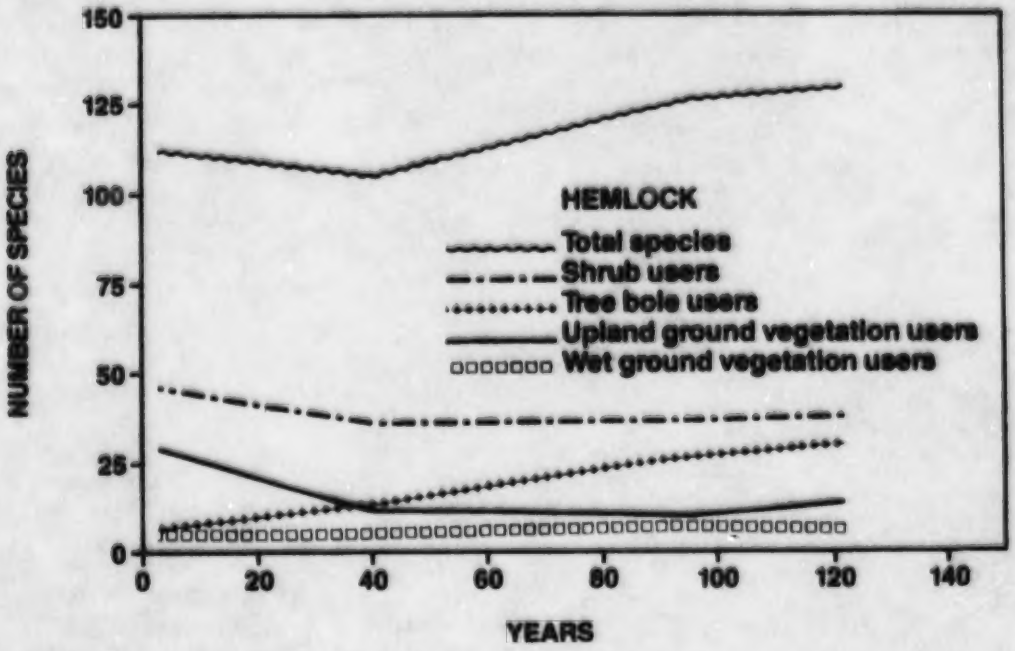
Hemlock trees can live up to 800 years. As they mature, they are often colonized by fungi that cause bole rot, which creates cavities. These cavities are used by birds and animals for denning or shelter (DeGraaf *et al.*, 1992).

When hemlock stands are disturbed through cutting or wind, microclimatic conditions of the understorey are changed. Light intensity and temperature increase, while relative humidity decreases. These changes may lead to the loss of species that depend on the understorey conditions of hemlock slope forests, such as the round-leaved orchis (MacDougall and Loo, 1996). Hemlock regeneration may be reduced under these altered conditions, as regeneration is most successful under shade (Godman and Lancaster, 1990).

The dense cover in hemlock stands provides winter habitat for deer, grouse and many other animals (Godman and Lancaster, 1990).

Some wild life species require older forests consisting of large-diameter trees with cavities, fallen logs and debris, and closed canopies. The following is a list of the species whose preferred breeding and/or winter habitat is mature hemlock forest: northern red-bellied snake, long-eared owl, solitary vireo, black-throated green warbler, and white-tailed deer (De Graaf et al., 1992).

Figure 3 shows how the number of animal species increases as stand age increases. Although plant species are not included in this graph, the occurrence of rare plants would be expected to follow a similar trend.



Mean d.b.h. (in)	2–4	4–6	6–8	10–12	12–14	14–16	16–18
Basal area (ft^2)	60–100	100–140	140–200	200–240	240–260	240–260	240–280
No. stems per acre	1000–3500	700–1000	600–700	300–350	250–300	200–250	150–175
Maximum height (ft)	10–20	30–50	50–70	60–80	60–90	70–90	70–90
Maximum d.b.h. (in)	6–8	8–10	12–14	14–18	18–22	22–24	24–26

Figure 3. Hemlock stand development and wild life species occurrence (De Graaf et al., 1992).

Habitat and Life History of Eastern Hemlock

Lifespan	300—800 years
Associations	These forests may include white pine, red spruce, and yellow birch; pockets of hemlock forest are often found within upland hardwood or mixed forest areas (MacDougall and Loo, 1996).
Shade tolerance	Very tolerant; it is one of the most shade tolerant of all tree species and can survive in as little as 5% sunlight (Godman and Lancaster, 1990).
Reaction to competition	Can withstand up to 400 years of suppression; new stands can be established under 70—80% crown closure; seedlings can be considered established when they are 0.9—1.5 m (3—5 ft) tall (Godman and Lancaster, 1990).
Seed production	Begins at 15 years and continues past 450 years; good crops in about 60% of years; seeds need stratification to break dormancy; it is one of the most frequent cone producers among eastern conifers but, despite this high frequency of cone crops, seed viability is unusually low and germination requirements are specific (Godman and Lancaster, 1990).
Soils	Shady ravines, streamsides, or north-facing slopes; all areas with cool, moist microclimatic conditions (MacDougall and Loo, 1996); probably more widespread on a wider variety of soils in the past (Power and Matson, 1995).
Rooting habit	Shallow on wet soils; deeper on better-drained soils; heavy cutting predisposes stands to windthrow; older exposed trees in partially cut stands are susceptible to radial stress cracks and ring shakes (Godman and Lancaster, 1990).
Seedbed	Thoroughly mixed organic and mineral soil, moist, shaded conditions (70—80% crown closure); without these conditions most eastern hemlock regeneration is restricted to rotten logs, stumps, and mounds that normally have warmer surfaces and better moisture retention than the forest floor; hemlock rarely germinates and becomes established in open areas and few germinate under a light overstorey because of the moisture stress created under these conditions (Godman and Lancaster, 1990).

Management Recommendations

Although shelterwood systems are often recommended as a way to manage hemlock, this would not maintain the appropriate conditions for the associated plants requiring shaded conditions. Thus, this system is not recommended for this community type.

As hemlock trees can live to be 800 years old, lack of regeneration under young stands (less than 200—300 years old) should not be cause for concern. Regeneration often develops when the stand eventually begins to break up.

Option 1

Core: Avoid disturbance.

Buffer: Maintain a 170-m (500-ft) buffer around the site to minimize edge effect. Use selection harvest to maintain 70—80% crown closure within the buffer. By maintaining high shade conditions and exposing mineral soil within the buffer, the proportion of hemlock may increase within this zone.

Another option is to underplant hemlock seedlings within the buffer if required.

Maintain a closed canopy over all extraction trails and try to keep them as narrow and as few as possible. Follow all guidelines under **"General Management Recommendations"** on page 10.

Option 2

Core: Minimize disturbance by single-tree selection harvesting and removal with a horse or small equipment. Maintain closed canopy with small gaps (70—80% crown closure), to minimize understorey competition growth and to increase chances of hemlock regeneration. Conduct harvest in a good cone year.

The large round-leaved orchis is a rare plant that is associated with some hemlock stands. Little is currently known about its specific site requirements. Where it is known to exist, avoid site disturbance until further information is available.

If regeneration is inadequate, underplant hemlock seedlings.

Buffer: See **"Buffer"** for **"Option 1"**

Pine—Oak Forest Community Type

The pine—oak forest community type is scattered and uncommon in New Brunswick in general, and is more common today in central and southern Maine. Pine—oak forest can be seen in the Rockville area along Big Bluff, Urney, and Waterford. These forests range from almost pure white pine to pure red oak (MacDougall and Loo, 1996).

Perley stated in 1847 that "*The white pine is most abundant between parallels of 43 and 48 degrees north latitude, and nowhere is it found of larger size, or of better quality, than in New Brunswick.*" This abundance and quality no longer exist due to unsustainable harvesting, white pine blister rust, and white pine weevil, which thrives in regenerating white pine forests after clearcut.

Importance to Wild Life

The understorey shrub layer is often sparse, especially under the pines, where thick layers of fallen needles reduce establishment of plants and shrubs. Plant species often found in association with pine—oak forest include sheep laurel, prince's pine, partridge berry, bunchberry, wood sorrel, wild lily-of-the-valley, and Indian pipe. Pinesap, an uncommon member of the wintergreen family, grows in this community type. A similar species, pine-drops, a very rare New Brunswick plant, occurs exclusively in mature pine forests, though it has not been recorded in the FMF area (MacDougall and Loo, 1996).

The seeds of white pine are a valuable food source for wild life, such as yellow-bellied sapsucker, black-capped chickadee, white-breasted nuthatch, pine warbler, pine grosbeak, and red crossbill. Some mammals that eat seeds, bark, and foliage include snowshoe hare, porcupine, red and grey squirrels, and mice (Wendel and Clay Smith, 1990). Acorns are eaten by insects, squirrels, small rodents, deer, mice, and numerous birds (Sander, 1990).

Blue jays are the primary dispersal agents for large numbers of heavy seeds, such as those of red oak. Blue jays collect and carry healthy acorns up to several miles from the parent tree, and bury them under leaf litter where they may germinate if conditions are right, and if the jays forget about them (Johnson and Adkisson, 1986). Gray squirrels were found responsible for much of the white pine regeneration under mature red oak stands in southern New Hampshire; they bury and recover the seeds (Sander, 1990). In this region, red squirrels and northern flying squirrels may serve the same purpose, as gray squirrels are relatively scarce.

Mature pine—oak forest provides preferred breeding, feeding, and winter habitat for the following species: northern red-bellied snake, sharp-shinned hawk, broad-winged hawk, red-tailed hawk, barred owl, downy woodpecker, pileated woodpecker, blue jay, American crow, white-breasted nuthatch, hermit thrush, wood thrush, black and white warbler, pine warbler, ovenbird, scarlet tanager, gray squirrel, northern flying squirrel, and black bear (De Graaf *et al.*, 1992).

As mature pine trees often tower above the forest canopy, they serve as important perching and nesting sites for many birds of prey, such as goshawk, red-tailed hawk, osprey, bald eagle, and others. Pileated woodpeckers also make extensive use of dying trees as drumming sites, perching, and calling posts. Because of their wind-firmness, they provide a source of vertical structural diversity in partial cuts and buffers.

Habitat and Life History of White Pine and Red Oak

Lifespan	**White pine**: 200—450 years; **red oak** 200—250 years.
Associations	Mixtures of white pine and red oak; red pine, jack pine, and beech may also occur (MacDougall and Loo, 1996).
Shade tolerance	**White pine**: intermediate; light intensity greater than 20% is imperative for survival; will reach maximum height growth with 45% light intensity (Wendel and Clay Smith, 1990); **red oak**: intermediate; light intensity of 30% for maximum height growth; light intensity is the most critical factor affecting survival and growth in the first year (Sander, 1990).
Reaction to competition	**White pine**: does not compete well during establishment period; once established it can survive suppression for up to 30 years (Wendel and Clay Smith,1990); **red oak**: does not compete well during establishment period and needs a good root system; once established it can survive suppression for up to 30 years; fine branching from dormant buds on tree trunks can be excessive in heavily thinned stands (Sander, 1990).
Seed production	**White pine**: good production begins at 20—30 years; cones take 2 years to mature; good crops are produced every 3—5 years; seeds are dispersed by wind and can travel up to 60 m in a stand and up to 210 m in the open (Wendel and Clay Smith, 1990); **red oak**: good production begins at 25 years, but crops do not become abundant until age 50; it takes 2 years for acorns to mature; good to excellent crops are produced every 2—5 years; acorns are dispersed over a small area by gravity, but squirrels, mice, and blue jays (Johnson and Adkisson, 1986) are the main dispersal agents; it takes about 500 acorns to produce one 1-year-old seedling (Sander, 1990).
Soils	**White pine**: well-drained, sandy soils, rocky slopes, knolls, and hilltops; **red oak**: deep, well-drained loam to silty, clay loams (MacDougall and Loo, 1996); as a species at the northern edge of its range, red oak requires much warmer than usual soil temperatures found on most NB sites; because of this, they often grow on shallow-soiled ridge tops, on rocky talus slopes and on deep, well-drained knolls in the FMF; the red oak—white pine community is mostly limited to hot, dry sites like those of Poley Mountain.
Rooting habit	**White pine**: deep rooted and windfirm; **red oak**: deep rooted and windfirm.
Seedbed	**White pine**: bare mineral soil is not necessary for seed germination; seeds can germinate on both disturbed and undisturbed litter layers; favorable seedbeds, in full sunlight, include moist mineral soil, mosses or light grass; drier sites benefit from light scarification and 50—70% shade which reduces soil temperatures and provides better moisture conditions; **red oak**: acorns germinate in the spring following seed fall and need to be in contact with soil, or buried in mineral soil, or covered with a light litter layer; consistent moisture is important until the tap root has developed, after which the seedling is somewhat drought tolerant; 50—70% shade reduces soil temperatures and maintains moisture; maximum height growth can be attained with 30% light intensity. More than 95% of red oaks in presently regenerating stands are sprouts from stumps of cut trees. The larger the parent stump the faster the sprouts grow. Thinning stump sprouts is not necessary for good growth (Sander, 1990).

Management Recommendations

The Society of American Foresters identifies White Pine—Northern Oak—Red Maple (Type 20) Forest as very close to a late successional or an alternating type of late successional forest on the sandy outwash plains of New England (Burns and Honkala, 1990). These forests can live for several centuries and can regenerate under their own canopy when openings are created. This allows a variety of alternatives to traditional even-aged management, which has usually been practised on all forest types. The Pine—Oak community type described here may have similar characteristics and develop under similar management systems.

White pine and red oak have similar site requirements and longevity. Both require little competition, with protection from full sun, and moist soil conditions, so that regeneration in light shade is ideal. Both white pine and red oak are associated with burned areas which often have sparse vegetation. This allows pine and oak to become established because they cannot compete with other vegetation during their establishment stage. Both can withstand suppression for up to 30 years, once established, but are initially poor competitors.

As with all potential late successional forests, they are capable of persisting indefinitely if not disturbed by clearcutting. Although this community type originates after fire, mature trees are capable of surviving fire which removes the understorey and creates a perfect seedbed. The warm, well-drained sites where these trees often grow in NB may mimic this situation because ground vegetation tends to be sparse, but the soils tend to be warmer. Red oak appears restricted to this habitat type because it requires more warmth to germinate than is found on many NB sites. As mentioned above, lack of moisture decreases seedling survival until the tap root is developed. After that, these species are relatively drought resistant.

Forest-grown oaks usually develop tall, straight trunks and large crowns while open-grown trees tend to have short trunks and spreading crowns (Sander, 1990). Until it reaches about 6 m, open-grown white pine is susceptible to the white pine weevil. These weevils lay their eggs in the wood of the main leader on the pine; when the eggs hatch, the larvae eat the wood and kill the shoot, causing stunted, deformed trees. Pines growing under shade are less susceptible to weevils. Thus the pine—oak relationship benefits both species because they provide shade for each other to germinate, allow self-pruning on the oak (creating a better-formed tree), and protect the white pine from the white pine weevil.

Common or rare plant species associated with this forest type probably require lower light intensities and sparse competition, as do most late successional species, because of their inability to compete with opportunistic, shade-tolerant species. Their moisture requirements and soil acidity needs may also be specific.

Option 1

Core: Avoid disturbance.

Buffer: Maintain a 170-m buffer around the site to minimize edge effect. Retain a crown closure between 50—70%, and scuff the soil surface to expose mineral soil, which will encourage pine and oak regeneration. By maintaining adequate shade conditions within the buffer zone, the proportion of oak and pine may increase over time.

Once oak regeneration reaches 1 m (3 ft) in height, it can compete with other hardwoods and can be released with a group selection harvest to increase its growth potential. The opening created should be from 10— 30m (0.25—0.67ac) in diameter (Leak *et al.*, 1987).

Collect and distribute acorns and/or underplant pine and oak seedlings within the buffer, if required.

Follow all guidelines under **"General Management Recommendations"** on page 10.

Option 2

Core: Minimize disturbance by single-tree selection with a horse or small equipment, retaining a mix of diameters and tree age. Leave some large, well-formed trees to continue to grow as both of these species can survive for several centuries. Maintain at least 70% crown closure, to minimize understorey growth and to increase chances of regeneration survival. Both of these tree species can grow well in 70% shade. Conduct harvest in a good seed year.

If regeneration is inadequate, collect and distribute acorns and/or underplant pine and oak seedlings.

If some of the rare plants associated with these sites are found, avoid disturbance until a specialist can assess the site.

Buffer: See **"Buffer"** for **"Option 1"**

Talus Slope Hardwood Forest Community Type

Talus, also known as scree, is an accumulation of rock debris that forms at the base of cliffs and escarpments and includes loose boulders, cobble, and sometimes gravels and finer sediment. The type of talus depends primarily on the underlying parent material of the area. Boulder talus tends to be harder, granitic rock material, while smaller cobble and gravel talus comes from softer sedimentary rock or slates. Within the FMF, talus slopes are known to occur in four areas: Hampton, Mount Zachie Jonah, Waterford, and Parlee Brook.

Talus slopes are unstable and prone to land slides and new rock falls from above. The stability of talus slopes varies, depending on their steepness and the size of the material. Upper talus slopes drain rapidly, and soil formation is limited to small pockets among the boulders, so these areas are dry with poor soil. Lower slope areas tend to accumulate soil and moisture. The nutrient status of talus areas depends on whether the parent material is acidic or basic. Basic sites generally support a richer community of plant species than acidic sites. Aspect and distance from coastal areas also influence species composition. Both northern aspect and proximity to the coast create cool and moist conditions that enhance the development of lichens and some other plants.

In downslope areas, or on upper talus fields where moisture is not limiting, a forest community may establish. Talus forests are typically composed of a variety of tree species such as sugar maple, yellow birch, balsam fir, white birch, beech, white pine, red spruce, and, on occasion, green alder. At two gravel-talus sites within the FMF, pure ironwood or ironwood—red oak stands occur (MacDougall and Loo, 1996).

The variety and types of talus communities can be delineated on a map based on the land classification system described by Power and Matson (1995). Most of these sites only survived because they were too rocky and steep to plow and can provide us with a window on forest types that were once more common. In a conservation program, the restoration of many old fields that were once forested with these species mixes, is an important step in maintaining this community type.

Importance to Wild Life

In the very dry boulder and rock talus with limited soil formation, plant growth is often restricted to primitive plants, such as fruticose, crustose, and foliose lichens, and the mosses, *Rhacomitrium canescens* and *Polytrichum* spp. These species are most likely to occur in boulder and rock talus because it is more stable than finer materials, and disruption is less frequent, allowing these species to become established.

The ground plants in forested talus often include several fern species: marginal shield-fern, glandular wood-fern, rock polypody, bracken fern, rusty woodsia, and the mountain wood-fern, as well as skunk-currant, Canada gooseberry, poison ivy, low-bush blueberry, whorled wood aster, large-leaved aster, and woodrush (*Luzula acuminata*). The ironwood talus sites, enriched by limestone, host bloodroot, false Solomon's seal, and the green woodland orchis. At least two uncommon plant species occur on talus slopes within the FMF: Herb-Robert, which is considered uncommon in New Brunswick, and the maple-leaved goosefoot, a rare species in the province that occurs in only three known locations, including Mount Zachie Jonah.

Talus slopes are also preferred habitat for two very rare shrew species in New Brunswick, the Gaspé shrew and the rock vole (Clayden *et al.*, 1984). Both are found in cool, mossy, talus areas, usually near streams. Neither of these species has been observed within the FMF, though thorough surveys have not been done. The rock vole was observed in nearby Albert County in 1979, and thus may occur in the FMF (MacDougall and Loo, 1996).

Management Recommendations

Option 1

Core: Avoid disturbance.

Buffer: Retain a 170-m buffer, with 50% crown closure, to reduce wind damage and minimize edge effect. Retain selected species, discussed on page 14, when possible.

Option 2 Due to unstable soil conditions, variety of tree species, and number of rare wild life species associated with this community type, an evaluation on a site-by-site basis would be the best precautionary approach before planned disturbance.

Wet Cedar Forest Community Type

In 1847 Perley wrote, "*It [cedar] abounds in favorable situations in New Brunswick.... A cool moist climate seems to be indispensable to its growth....but is found on the rocky edges of the innumerable streams and small lakes scattered over New Brunswick. It frequently occupies exclusively, or in great part, swamps from fifty to one hundred acres in extent, some of which are accessible only in the winter, when they are frozen and covered with deep snow. It abounds exactly in proportion to the degree of humidity, and in the driest marshes, it is mingled with the black spruce, hemlock spruce* [hemlock], *the yellow birch, the black ash, and a few stocks of the white pine.*" This describes the abundance of cedar 150 years ago, but today the number of cedar stands is continually declining.

Wet cedar swamps are scattered and uncommon within the FMF, occurring along the St. John River and also near Salisbury. When cedar stands are cut, or flooded by the damming of adjacent wet areas, many or all of the associated rare species are adversely affected by the disturbance and may disappear. While cedar may re-establish on these sites, rare plant species are less likely to do so. Their distribution is restricted and the distance of seed movement is limited, so they may not be able to colonize regenerated sites. As a result, remaining undisturbed cedar stands serve as critical habitat for the maintenance of species that may now be considered threatened in New Brunswick (MacDougall and Loo, 1996).

Wet cedar forests may provide habitat for a large number of uncommon plants, including species of rare orchids. This is primarily true for mature cedar stands, older than 100 years, which have not been intensively harvested. As a result of habitat loss, however, these forests are now very uncommon within the FMF and in New Brunswick in general (Woodley and Forbes, 1997). One New Brunswick study shows a strong correlation between residual cedar trees (mature trees left on site after the harvest) and cedar regeneration on 10-year-old harvest sites, while clearcut sites show little or no cedar regeneration (Zelazny and Veen, 1997). This indicates the need for alternative harvesting methods in order to maintain a cedar component on future forest sites. Although the focus of these recommendations is on wet cedar forests, upland cedar sites are also at risk and should be managed in a similar way.

Eastern white-cedar forest is exceedingly stable because the tree is long lived and the wet sites are not prone to fire. Budworm and other insects that live on many conifers do not attack cedar. The primary threat to these stands is human disturbance. At present, many cedar stands have been opened by timber harvesting or severely browsed by white-tailed deer and succession is often composed of red maple or poplar (Zelazny and Veen, 1997).

Importance to Wild Life

Sites that are especially rich in lime and undisturbed by logging often have a very diverse understorey. Commonly observed species include sheep laurel, bog goldenrod, three-leaved false Solomon's seal, bunchberry, and marsh fern. Less common are royal fern, wood anemone, naked mitrewort, alder-leaved buckthorn, blunt-leaved orchis, and the heartleaf twayblade. A number of rare plant species also occur in these sites, including several sedge species, and Hooker's orchis. Also occurring on these sites are boreal aster, reported as very rare, and showy lady's slipper, which is listed as rare, and possibly endangered in New Brunswick. Its numbers have been drastically reduced by habitat loss and by pickers and collectors (Hinds, 1986). Yellow lady's slipper is uncommon for similar reasons (MacDougall and Loo, 1996).

The dense cover provided by cedar stands is critical winter habitat for white-tailed deer and the foliage is a favored browse for them as well as for snowshoe hare, porcupine, and red squirrel. These trees are used for feeding and/or breeding by several warblers (northern parula, black-throated green, blackburnian, and magnolia), white-throated sparrows, kinglets, and pileated woodpeckers (Johnston, 1990).

Habitat and Life History of Eastern White-Cedar

Lifespan	150—400+ years
Associations	Varying amounts of black spruce, larch, and red maple (MacDougall and Loo, 1996).
Shade tolerance	Tolerant to very tolerant
Reaction to competition	Does not compete well with heavy vegetation; can withstand severe suppression for several years; grows well in 50% light intensity (Johnston, 1990).
Seed production	Good production begins at 30 years, but crops do not peak until age 75; cone crops are produced every 2—5 years; seed dispersal begins in September; wind dissemination range is from 45—60 m under normal conditions (Johnston, 1990).
Soils	Poorly drained areas typically associated with open peatlands and small ponds. These forests are sometimes called "cedar bogs" because of dense mats of sphagnum that form to varying depths in the substratum (Maine Natural Heritage Program, 1991). Wet cedar forests typically develop on calcium-rich soils that have a higher pH than is normally found in wet conifer forests dominated by larch or black spruce (MacDougall and Loo, 1996). Although cedar does grow on upland sites, the focus here is on wet cedar sites only.
Rooting habit	Shallow rooted and not windfirm; blowdown can be a major problem in stands opened up by forestry operations.
Seedbed	Seed dormancy is broken after the first winter and remains viable for one year; germination is best on moist, warm, neutral to slightly acid soils free of heavy slash (Johnston, 1990). In undisturbed areas, more than 70% of seedlings grow on decaying (rotten) wood of logs and stumps. These seedbeds usually are more moister, warmer, and have less smothering litter than other seedbed types (Johnston, 1990). Probably more stems originate by layering rather than from seed, because vegetative reproduction is more tolerant of shade and is never without an adequate root system (Johnston, 1990).

Management Recommendations

Road construction and layout must be done carefully to minimize potential changes in water levels within these sites. These forest community types are especially sensitive to increased water levels for extended periods, which drown the trees and associated rare plants. Wetland road crossings without adequate drainage and beaver damming are primary causes of flooding. Road-caused flooding has killed white cedar or reduced its growth on thousands of hectares in northern Minnesota (Johnston, 1990) and is a common problem in NB. Natural gas and petroleum pipelines will probably have similar effects unless adequate cross drainage can be provided.

Option 1

Core: Avoid disturbance.

Buffer: Maintain a 170-m buffer to minimize edge effect and reduce blowdown. Where possible do not reduce the crown closure within this buffer below 50%, and scuff mineral soil to encourage cedar regeneration. Moisture retention and minimum competition increase success with cedar regeneration.

If regeneration is poor, and site conditions are acceptable, underplant cedar seedlings to increase the cedar component. Sometimes the buffer may have different soil types and naturally host different tree species, e.g., spruce or larch.

Follow all guidelines under **"General Management Recommendations"** on page 10.

Option 2

Core: Conduct a winter harvest to minimize damage to ground vegetation and compaction of wet soils; remove a maximum of 20% basal area to minimize blowdown and maintain at least 75% crown closure to provide shade. Conduct harvest in a good seed year.

There are concerns about the ability of some rare plants associated with these sites to reestablish after disturbance. Where some of the rare plants associated with these sites are known to exist, avoid disturbance until more information is available.

If cedar regeneration is inadequate, underplant cedar seedlings.

Buffer: Maintain a 170-m buffer to prevent blowdown within the cedar stand, with a crown closure of at least 50% within this buffer. Scuff mineral soil to encourage cedar regeneration and underplant cedar seedlings if required.

Haul roads must be constructed in a way that avoids flooding the site, which will kill the trees and associated plants. The suggested 170-m (500-ft) road buffer may not suffice on these sites depending on drainage, so site assessment needs to be done thoroughly.

Follow all guidelines under **"General Management Recommendations"** on page 10.

Coastal Ravine Red Spruce Forest Community Type

The ravines along the Fundy coast have steep slopes, often covered with large, old red spruce. Harvesting these trees could cause severe erosion and would destroy a forest stage no longer found elsewhere in FMF (Woodley and Forbes, 1997).

Coastal ravine red spruce trees often reach larger sizes than trees in the adjacent upland plateau forests. This reflects both the suitable growing conditions in the ravines and the age of the trees, which were not harvested because of the steepness of the slopes. Some of these untouched forest patches include trees more than 300 years old (MacDougall and Loo, 1996).

This species has a restricted geographic range in northeastern North America (see Figure 4). The area of red spruce originally present in the Southern Appalachians has been reduced to about one-fifth of what it once was by fire and clearcutting (Blum, 1990). A similar trend is seen in New Brunswick as 5-year post-harvest regeneration surveys reveal a decline in the abundance of red spruce (Forest Ecology Site Group, 1995).

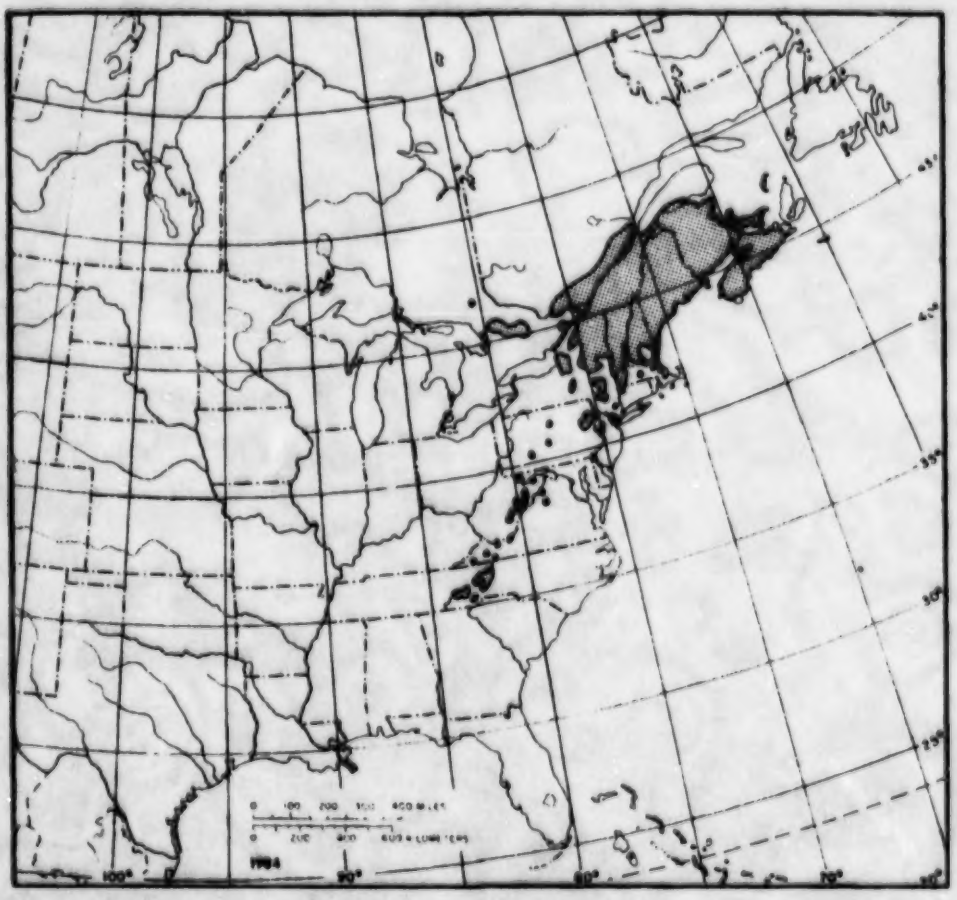


Figure 4. Geographical range of red spruce (reprinted from Blum, 1990).

Importance to Wild Life

Soil variations among ravines result in differences in species diversity and composition, especially for the rare arctic-alpine species found at these locations (Woodley and Forbes, 1997). This indicates how sensitive these sites may be, depending on soil type and availability, light conditions, and moisture. Rare arctic-alpine plants often grow on almost bare rock and are very sensitive to disturbance.

Forest cover types that include red spruce support a wide variety of wild life. They are particularly important as winter cover for deer, moose, ruffed grouse, and snowshoe hare, as well as for woodcock, which return to NB in late March and still need protection from the variable weather conditions. Many song birds and fur bearers also frequent these forest types (Blum, 1990). The red spruce forests of the FMF coastal ravines are known breeding sites for the rare Bicknell's Thrush, a species largely restricted to cool, remote, upland forests (MacDougall and Loo, 1996).

Mature red spruce provides preferred or possibly critical breeding and winter habitat for the following species: spruce grouse, black-backed woodpecker, gray jay, boreal chickadee, red-breasted nuthatch, golden-crowned kinglet, ruby-crowned kinglet, Swainson's thrush, solitary vireo, northern parula, Cape May warbler, blackburnian warbler, bay-breasted warbler, red crossbill, white-winged crossbill, pine siskin, evening grosbeak, red squirrel, deer mouse, porcupine, and marten (De Graaf *et al.*, 1992).

Threats

The most important insect enemy of red spruce is the spruce budworm (*Choristoneura fumiferana*). Red spruce is much less vulnerable to damage than balsam fir or white spruce, largely due to later bud flushing in the spring (Blum, 1990) and the relative inability of budworm to thrive on foliage older than one year. The cool coastal climate in the FMF may further suppress the timing of red spruce bud flush, providing more protection.

All along the eastern Appalachian mountain chain, from the New England states to Georgia, growth has declined in high-elevation red spruce since the 1960s. This decline has been accompanied by increased mortality and crown damage, which may be the result of air pollutants and/or ozone exposure (Blum, 1990).

Red spruce and black spruce may cross pollinate under the right environmental conditions to become a red—black cross (*X*). This hybrid then has some characteristics of each parent species. Red spruce is shade tolerant and regenerates well under a crown canopy. Black spruce requires more light and grows much faster than red spruce in an open situation.

Red spruce stands that have been clearcut may not regenerate back to red spruce. Often, spruce regeneration after such cuts appears to have characteristics of both red and black spruce, even when there is little black spruce in the surrounding area. It is assumed that black spruce and red X black hybrids can out-compete red spruce seedlings in the open, because these trees prefer higher light conditions. This situation would rarely be seen under closed canopies because red spruce requires more shaded conditions during its establishment period and can out-compete black and hybrid spruce. Thus selection harvesting may be important to maintain the integrity of the red spruce gene pool.

Habitat and Life History of Red Spruce

Lifespan	250—400+ years
Associations	Mixtures of balsam fir, black spruce, red maple, white birch, and yellow birch; white pine occurs infrequently on ridge tops, where the soil is thin over bedrock (MacDougall and Loo, 1996).
Shade tolerance	Tolerant to very tolerant.
Reaction to competition	Can withstand severe suppression for up to 145 years, but may require up to 5 years to respond to release; balsam fir and hemlock may outgrow red spruce after release; it can become established under 90% shade, but grows best in 50% shade or less (Blum, 1990).
Seed production	Good cone crops are produced every 3—8 years; seed dispersal begins in September to early October (Blum, 1990).
Soils	Well-drained to moderately well-drained, coarse textured soils that are often thin and poor in nutrients (MacDougall and Loo, 1996).
Rooting habit	Shallow rooted and not windfirm; blowdown can be a major problem in stands opened up by forestry practices.
Seedbed	Seed dormancy is broken over the first winter and seed remains viable for one year; germination is from May to early July and adequate moisture is the chief limiting factor that makes mineral soil an excellent medium because soil moisture and temperature are less variable than in other media; the wind dissemination range is up to 100 m (330 ft) from the forest edge. Spruce seedlings have an exceptionally slow-growing, fibrous, shallow root system and duff layers greater than 5 cm (2 in) may cause high mortality due to drying. This contributes to their lack of success after clearcutting. Once seedlings are 15 cm (6 in) high they can be considered established (Blum, 1990).

Management Recommendations

Most of the major forest cover types in which red spruce is a component are considered late successional forests (Blum, 1990).

Option 1

Core: Avoid disturbance. Harvesting these steep slopes could cause serious erosion problems that would affect the quality of the site and the aquatic ecosystems below. As MacDougall and Loo (1996) point out, old log slides where logs were pushed down the sides of ravines to be floated to market remain unvegetated after 100 years.

Buffer:

The steep river valley slopes of the FMF present an additional concern for water quality in the area and unique and sensitive conditions that should be specifically identified in buffer zone guidelines (Woodley and Forbes, 1997).

Maintain a buffer setback of 170 m beginning at the top of the valley, at a point where the slope is <20% (Woodley and Forbes, 1997). Harvesting systems that create small openings, to avoid summer drying and drying by prevailing winds, are required to maintain a red spruce component in any forest type (Salonius, *pers. comm.*, 1998).

Conduct a selection harvest to create small openings in the canopy, retain a crown closure of 60—70% and scuff soil during extraction. Underplant red spruce seedlings in small openings if regeneration is insufficient.

Follow all guidelines under **"General Management Recommendations"** on page 10.

Sugar Maple—White Pine Inland Cove Forest Community Type

The inland cove forest community type occurs in broad, sheltered coves, both along the shores of lakes and bays, and on the low to mid-elevation slopes above them. The cove habitat is characterized by rich, moist soils with climatic extremes moderated by the influence of the adjacent water bodies and protected by the cove headlands.

In the FMF, cove forests occur along Washademoak Lake and Belleisle Bay. They have rich and diverse communities of plants, with mixes of species typical of both rich northern hardwood community types and coniferous community types. Dominant tree species are sugar maple, white pine, and yellow birch, with eastern white-cedar, ironwood, red maple, white and black ash, red pine, and red spruce.

Cove forests occur in only a few locations in the FMF, because many have been affected by early land clearance for settlement or agriculture, or more recently for cottage development. Remaining sites are threatened by new development (MacDougall and Loo, 1996).

Importance to Wild Life

Ground plants include bunchberry, sundrops, blue flag, wood sorrel, intermediate wood fern, oak fern, jack-in-the-pulpit, and the rush, *Carex tribuloides*. At Big Cove along Lake Washademoak, checkered rattlesnake plantain, a member of the orchid family, was recorded. This species is considered uncommon in New Brunswick (MacDougall and Loo, 1996).

These areas serve as important riparian zones to protect water quality and provide cover for many species of wild life, allowing them to move from one area to another. They also serve as valuable nesting and perching areas for birds of prey, such as the bald eagle and osprey.

For other wild life uses of associated tree species see **Pine—Oak Community Type** on page 22 under the heading "*Importance to Wild Life*" and also see **Sugar Maple—White Ash— Ironwood—Beech Community Type** on page 40 under the heading "*Importance to Wild Life*".

Habitat and Life History of White Pine—Sugar Maple Community Type

As most of the life histories of the individual species are described in other community types, they are not listed here. Please see **Pine—Oak Community Type** on page 23 under the heading *"Habitat and Life History of White Pine and Red Oak"* and also see **Sugar Maple—White Ash—Ironwood—Beech Community Type** on page 42 under the heading *"Habitat and Life History"* for detailed descriptions.

Management Recommendations

Option 1

Core: Avoid disturbance.

Buffer: Maintain a 170-m buffer zone to minimize edge effect. Maintain a 70% crown closure within buffer to encourage regeneration of selected species. Retain healthy white pine, sugar maple, and as many of the associated species as possible as potential seed sources. Try to retain a similar proportion of tree species on site after harvest; *e.g.*, if there was 20% pine before harvest, try to retain pine as 20% of the remaining trees. Scuff soil during extraction to encourage white pine and yellow birch regeneration. Create openings less than 10 m (30 ft) wide to encourage sugar maple and up to 20 m (60 ft) wide to encourage pine (Leak *et al.*, 1987).

Underplant white pine, sugar maple, and associated species seedlings within the buffer if required.

Cottage development should be outside the buffer zone to protect the integrity of the site. Perhaps small pathways leading to the water's edge would suffice for recreationists. This would be similar to current campsite permits on Crown land. Follow all guidelines under **General Management Recommendations** on page 10.

Option 2

Core: Conduct a partial harvest, retaining a 75% crown closure, maintaining roughly the same proportions of existing tree species. The openings (25% open canopy) should be 20 m wide for pine or as smaller gaps to accommodate sugar maple regeneration (Leak *et al.*, 1987). Most of the associated species are highly to moderately tolerant of shade and should be able to regenerate under this type of system.

Buffer: Retain a 170-m buffer zone with a 70% crown closure. Retain a variety of diameters and ages of pine, sugar maple, and associated species to increase chances of regeneration. Lightly scuff soil during extraction.

Underplant white pine, sugar maple, and associated species seedlings within buffer if regeneration is inadequate.

If cottage development is planned, implement development as described in Option 1 above.

Follow all guidelines under **"General Management Recommendations"** on page 10.

Rich Northern Hardwood Forest Community Type

Rich northern hardwood forest comprises two different community types in the FMF: the sugar maple—white ash—ironwood—beech forest group and the silver maple—American elm alluvial bottomland group. Both exist as small, discrete forest patches within the FMF due to limited habitat availability, and land clearance for agriculture.

Because of the fertile nature of areas supporting the two northern hardwood forest community types, they were typically the first lands to be cleared following European colonization. Today, very little remains forested or, if it is forested, the successional stage and age distribution are characteristic of abandoned farmland reverting to forest. Distribution of both community types was likely always restricted in the FMF because suitable habitat was limited. However, habitat alteration has further reduced and fragmented sites to the point that species may no longer be able to persist, especially those requiring the shady, moist conditions provided by mature, closed-canopy forest (MacDougall and Loo, 1996).

Sugar Maple—White Ash—Ironwood—Beech Community Type

The sugar maple—white ash—ironwood—beech community type occurs on mid-slope and rich upland soil sites derived directly from limestone parent material, or sedimentary parent material with a limestone component. Their elevation results in more frost-free days than in the valley bottom such as at Havelock and in the Sussex area. This community type differs from the more common sugar maple—yellow birch—beech community type found in less fertile areas of the FMF (MacDougall and Loo, 1996).

These tree species were probably once much more common than they are today. In 1863, Moses H. Perley wrote,

> *"The white ash is an interesting and valuable tree ... it abounds in New Brunswick.*
>
> *Of the several species of maple, the most interesting and the most valuable is the sugar-maple, also known as the rock maple and hard maple. It enters largely into the composition of the forests with which New Brunswick is covered, where it is found of the largest size, and in great perfection."*

In 1847, he described beech, ironwood, and butternut. Of beech, he wrote: *"This species of beech ... In some parts of New Brunswick, and generally in Prince Edward Island, it is so abundant as to constitute extensive forests, the finest trees growing on fertile, level, or gently sloping lands, which are proper for the culture of grain."* Today almost all beech trees growing in southern New Brunswick have been stunted and deformed by an introduced insect and fungus combination commonly known as beech bark disease.

Of ironwood, he wrote: *"Though the iron wood is multiplied in the forests of New Brunswick, it nowhere forms masses even of inconsiderable extent, but is loosely disseminated, and found only in cool, fertile, and shaded situations."*

He also wrote about butternut: *"Very considerable quantities of furniture are now made at Fredericton of butternut wood, which is now becoming in great request for a variety of purposes."* At one time, butternut was much more common in the FMF. The community of Havelock was once named Butternut Corner and a nearby location was called Butternut Ridge. Today, few butternuts remain in the Havelock area, probably less than 20 trees, of which several are ornamentals. With the rapid spread of the butternut canker (*Sirococcus clavigignenti-juglandacearum*) in the United States and central Canada, the future of this species is uncertain (MacDougall and Loo, 1996).

Today, butternut is found growing along the alluvial flood plains of the Kennebecasis River, Trout Brook, St. John River shoreline, and Belleisle Bay. Unfortunately, the butternut canker, which has decimated US populations, has been found in western NB and will probably spread throughout the province.

Importance to Wild Life

Common ground plants in these forests include Dutchman's breeches, Indian cucumber-root, spring beauty, rattlesnake fern, red trillium, Solomon's seal, and trout lily. Several species are listed as uncommon, rare, or very rare for New Brunswick, including blue cohosh, wild leek, grove meadow-grass (*Poa alsodes*), and a species of black snakeroot (*Sanicula trifoliata*) which has not been seen in the Sussex area since 1885 and is now believed to be extirpated. It can still be found in the central St. John region near Woodstock.

For many plant species, fragmentation and habitat conversion may also affect migration along river valleys because distances from one patch to another may be greater than the seeds or pollen can naturally travel (MacDougall and Loo, 1996). Large openings also increase the risk of weedy plants taking over the site and displacing these less aggressive species.

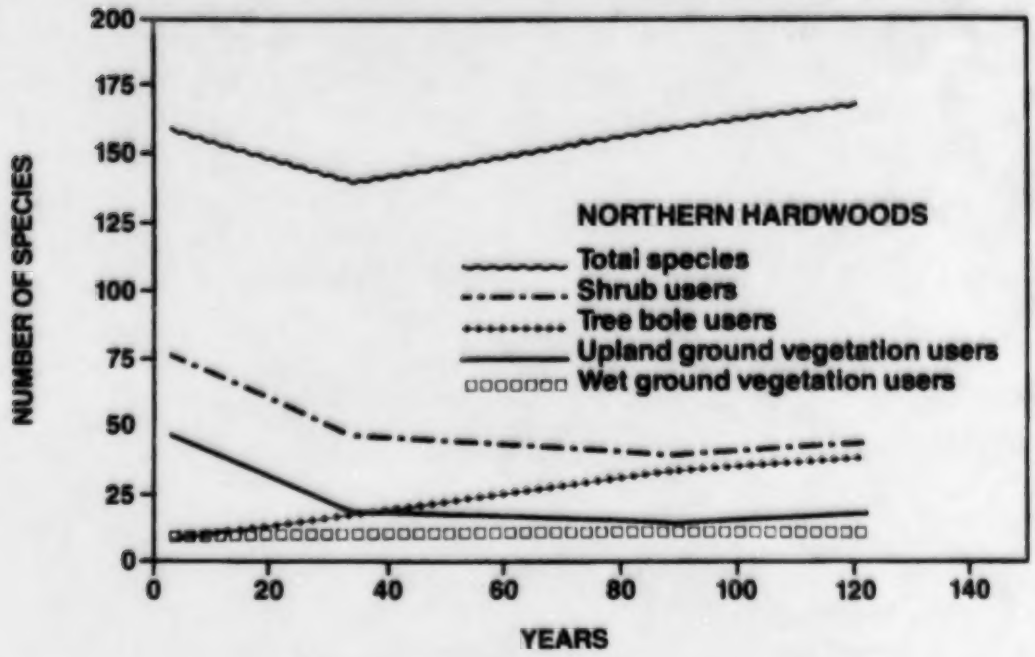
The community type provides suitable habitat for many breeding bird species. Most common are the red-eyed vireo, ovenbird, and American redstart. Uncommon or rare species include scarlet tanager and wood thrush. These species were likely never abundant within New Brunswick, which is the northern limit of their natural range. However, they may have been more prevalent before colonization when mature, broad-leaved forest was more widespread (Erskine, 1992).

Numerous animals feed on sugar maple, such as deer, red, grey and flying squirrels (which gnaw buds, foliage, and twigs or feed on the seeds), and sapsuckers, which drill feeding holes in the trunk. Buds and catkins of ironwood are important winter food for ruffed grouse; the nuts are secondary food in the fall and are eaten to a lesser extent by red and grey squirrels, white-tailed deer, purple finch, rose-breasted grosbeak, and downy woodpecker (Metzger, 1990).

Beech mast is eaten by a large variety of birds and mammals, including mice, squirrels, chipmunks, black bear, deer, foxes, ruffed grouse, ducks, and blue jays. Beech is the main nut-producing tree in the northern hardwood type (Tubbs and Houston, 1990); however, diseased trees produce few nuts. Studies in northern New Brunswick indicate downy woodpeckers foraged on 78—88% of beech trees present in the stand. This was the preferred species for winter foraging, with more use on 30- to 40-cm live, often diseased beech trees, as opposed to dead trees (Villard, 1997). White ash seeds are eaten by the wood duck, purple finch, and pine grosbeak (Schlesinger, 1990).

The following species prefer mature northern hardwood forests for feeding, breeding and winter habitat: northern red-bellied snake, sharp-shinned hawk, northern goshawk, broad-winged hawk, barred owl, ruby-throated hummingbird, downy woodpecker, hairy woodpecker, pileated woodpecker, least flycatcher, black-capped chickadee, white-breasted nuthatch, hermit thrush, wood thrush, red-eyed vireo, black-throated blue warbler, black-throated green warbler, black and white warbler, ovenbird, scarlet tanager, smoky shrew, northern flying squirrel, woodland jumping mouse, porcupine, black bear, and fisher (De Graaf et al., 1992).

Figure 5 shows how the number of wildlife species increases as hardwood forests age. Although plant species are not included in this graph, the occurrence of rare plants would show a similar relationship.



Mean d.b.h. (in)	2–4	4–6	6–8	8–10	10–12	11–13	12–14
Basal area (ft^2)	50–70	90–100	100–110	100–120	100–120	100–130	100–130
No. stems per acre	1000–2000	500–1000	300–500	200–300	150–200	100–150	80–120
Maximum height (ft)	30–40	40–60	50–70	60–80	70–90	80–100	80–100
Maximum d.b.h. (in)	8–10	10–12	12–14	16–18	18–20	20–24	20–26

Figure 5. *Northern hardwood stand development and wild life species occurrence (De Graaf et al., 1992).*

Habitat and Life History

Due to the number of species within this associated community type, the life history for each will not be provided separately; instead, they will be viewed as a group.

Lifespan

Sugar maple: 300—400 years; **beech**: 300—400 years; **white ash**:100—200 years; **ironwood**: 50—140+ years; **basswood**: 150—200+; **butternut**: 75 years.

Associations

Occasionally basswood and butternut; black cherry is also found near Longs Creek, which flows into Waahademoak Lake.

Shade tolerance

Sugar maple - very tolerant; **ironwood** - tolerant; **beech** - very tolerant; **white ash** - tolerant in seedling phase, becomes intolerant as it matures; **butternut** - intolerant; **basswood** - tolerant.

Reaction to competition

According to Godman *et al.* (1990) **sugar maple**: grows well in 25% light intensity, can survive for long periods in heavy shade; excessive light causes dormant buds to produce numerous branches on the trunk of the tree; **beech**: similar to sugar maple; beech and sugar maple are recognized as climatic late successional species in the northern hardwood types of the Northeast; **white ash**: can persist for a few years in moderately dense shade and then respond quickly to openings in the canopy; **ironwood**: reproduces well under full shade. The species typically grows in late successional forests in the northern part of its range. Ecologists rank it high in their ratings of species climax potential; **basswood**: shading aids in establishment and initial survival, grows well in partial shade; **butternut**: does not survive shade from above; it must be in the overstorey to survive.

Seed Production

Sugar maple: moderate seed production begins at 70—100 years old, but high production does not begin until the trees are sawlog size; good crop years are from 3—7 years apart; seed dispersal by wind up to 100 m (330 ft) (Godman *et al.*, 1990); seed is commonly collected and buried by red squirrels, often giving rise to 30 seedlings germinating over a couple of square inches; **beech**: undiseased trees begin to produce nuts at age 40 and by the age of 60 may produce large quantities; good crops are produced every 2—8 years; dispersal is restricted, most nuts fall to the ground beneath the parent tree; rodents may carry some of them a short distance (Tubbs and Houston, 1990), while bluejays may carry them several kilometers (Johnson and Adkisson, 1986); **white ash**: begins production by age 20 with about 50% germination; seeds are dispersed by wind up to 140 m (460 ft) (Schlesinger, 1990); **ironwood**: seed production begins at age 25 with 27—65% germination (Metzger, 1990); dispersal is by wind and birds; **basswood**: produces seed from age 15—100 years; it produces good seed crops about 60% of the time, but only about 5% of the fruit survives; dispersal is only 1—2 tree lengths by wind, but can be further with the aid of animals; according to Neil Lamson (*pers. comm.*, 1998), most basswood comes from stump sprouts, either from cut trees or blowdown and are quite intolerant, although trees grown from seedlings can grow in partial shade; **butternut**: produces seed from age 30—60 years with good crops every 2—3 years; seed dispersal is by gravity, squirrels and other rodents (Rink, 1990).

Soils	Occur on mid-slope and rich upland soils derived directly from limestone parent material, or sedimentary parent material with a limestone component (MacDougall and Loo, 1996).
Rooting habit	Most of these trees are moderate to deep rooted; blowdown is not a major concern.
Seedbed	Most of these species require the cool, moist conditions found under a shady overstorey and a period of stratification; most can establish on an undisturbed forest floor; seed viability is one year on the forest floor; most of these trees will produce stump sprouts, but this is especially important in basswood since so few originate from seed in the wild.

Management Recommendations

This community type is composed primarily of potential late successional tree species and, as such, is capable of sustaining itself indefinitely if not heavily disturbed. The exception is the butternut tree, which is a short-lived intolerant species and requires a different management regime than the majority of the group. Due to the spread of butternut canker, management of this species may not be successful. Although basswood grown from seed is tolerant, its stump sprouts are not, and if the only basswood regeneration is stump sproute it needs to be managed as an intolerant (Leak *et al.*, 1987).

Option 1

Core: Avoid disturbance.

Buffer: Maintain a 170-m buffer to minimize edge effect. Retain all uninfected beech, but do not remove more than 30% of the total beech component due to its importance as winter forage. In order to maintain this amount of beech, some diseased stems will have to be left. Over time, diseased trees can be replaced with healthy trees, if a source exists. Retain sugar maple, ash, basswood, and butternut as potential seed sources. Maintain crown closure of 75% within the buffer to encourage regeneration of tolerant species. If clear beech exist, their proportion can be increased by encouraging root sprouting. Stumps should be cut as low as possible. Light wounding of clear trees in spring will established undiseased suckers.

If the site is **predominantly butternut**, create 30-m (0.67-ac) wide openings around selected butternut trees to encourage regeneration. Seedlings require moist, shaded conditions to become established, but should be released in their second year to full sunlight. Choose individual crop trees and maintain openings around them until they are above the competition.

If **basswood stump sproute** are present and seedlings are not, manage by group selection, with the basswood stump as the center of the group.

The opening should be at least 30 m (0.67 ac) wide (Leak *et al.*, 1987).

Underplant seedlings of selected tree species, except butternut, which fares better in open conditions. Collect butternut fruit and scatter them around the perimeter and in openings within the buffer.

A number of rare plants have been associated with these sites. Very little is known about their reaction to disturbance. Follow all guidelines under **"General Management Recommendations"** on page 10.

Option 2

Core: Conduct a partial harvest, maintaining a crown closure of about 75%. Retain all undamaged beech and favor undamaged sugar maple and ash. Do not remove any butternut or basswood, unless diseased, from the existing stand.

Conduct the selection harvest in a good seed year, using single-tree and group selection to produce gaps from 5—20 m across (Leak *et al.*, 1987), to accommodate tolerants and intermediates.

Create 30-m wide openings around **selected butternut trees** to encourage regeneration. Seedlings require moist, shaded conditions to become established, but should be released in their second year to full sunlight. Maintain these conditions until the seedlings are above their competitors. A crop-tree release would work well for this species because it cannot survive heavy shading.

If **basswood stump sprouts** are present, manage by group selection, with the basswood stump as the center of the group. The opening should be at least 30 m (0.67 ac) wide (Leak *et al.*, 1987).

Buffer: Maintain buffer as described in Option 1 above.

Special Management Areas:

Seeps and wet areas within these stands are of special concern because most of the rare plants tend to grow here. These areas must be left undisturbed with at least a 30-m wide buffer to maintain the necessary shaded conditions. A single-tree selection winter cut, maintaining 90% crown closure within the buffer would protect these sites, provided they were marked during the field season. Avoid locating roads near these seeps.

Follow all guidelines under **"General Management Recommendations"** on page 10.

Silver Maple—American Elm Alluvial Bottomland Community Type

The silver maple—American elm alluvial bottomland community type occurs on alluvial deposits found on the low-elevation bottomlands of river and lake valleys. Most plant species of this community type can tolerate occasional seasonal flooding. The locations of alluvial deposition in the FMF are typically small in area and, as a result, this forest community is only found in small, discrete patches (MacDougall and Loo, 1996).

Silver maple appears as a dominant species only in streamside communities and on the fringes of lakes and backwaters of streams (Gabriel, 1990). Although the species may have a broad range, its suitable habitat is restricted.

American elm has been greatly reduced throughout North America by the Dutch elm disease, introduced from Europe in the 1930s. Some studies suggest the species may be able to survive for generations to come, although the lifespan of the trees may be reduced. More detail on this subject may be found in Bey (1990).

Importance to Wild Life

Typical ground plants include: jack-in-the-pulpit, Dutchman's breeches, Indian cucumber-root, spring beauty, nodding trillium, carrion-flower, and trout lily. Species listed as scattered, uncommon, or rare include golden alexanders, maidenhair fern, Canada lily, and the lance-leaved grape-fern. Maidenhair fern has not been recorded since the 1950s and may no longer exist in the area. It had originally been observed in the Belleisle Bay area (MacDougall and Loo, 1996).

The buds of silver maple provide a vital link in the food chain of squirrel populations because the early swelling and budburst typical of this species come during the critical late winter-spring period when stored food supplies of squirrels are exhausted (Gabriel, 1990). Baltimore orioles, warbling vireos, and great-crested flycatchers depend on these forests for critical breeding and feeding habitat.

Local studies conducted on the floodplains of New Brunswick show that silver maple ranks far above other dominants on wet, rich sites as nesting trees for wood ducks and goldeneye ducks (Gabriel, 1990), as well as for hooded mergansers and common mergansers.

Elm provides a food source for many mammals and birds including gray squirrels, mice, and occasionally, ruffed grouse. "*Because its litter decomposes rapidly and contains many desirable nutrients, American elm is considered a soil-improving species*" (Bey, 1990). This characteristic may provide for specific habitat needs of some of the associated plants.

Life History of Silver Maple and American Elm

Lifespan	**Silver maple:** 80—130+ years; **American elm:** 150—200 years.
Associations	More common species are black ash, red ash, red maple, and black willow; less common species are butternut, white cedar, basswood, and bur oak (MacDougall and Loo, 1996).
Shade tolerance	**Silver maple:** ranges from moderately tolerant on good sites to very intolerant on upland soils; **elm:** intermediate; young forest trees may sunscald when exposed by harvesting or thinning operations (Bey, 1990).
Reaction to competition	**Silver maple:** depends on site characteristics; initial growth of seedlings may be rapid, ranging from 30—90 cm (12—36 in.) in the first year but, as they cannot compete with overtopping vegetation, first-year mortality is high if they are not released (Gabriel, 1990); **elm:** can persist in the understorey of pioneer species with light shade, but does not survive heavy shade; seedlings perform best with about one-third sunlight during the first year. After the first year or two, they grow best in full sunlight (Bey, 1990).
Seed Production	**Silver maple:** annually produces abundant seed that are disseminated by the wind and occasionally by water; minimum seed-bearing age is 11 years (Gabriel, 1990); **elm:** begins seed production at age 40, and is a prolific seed producer at maturity; seeds are disseminated by wind up to 91 m (300 ft) from the parent tree; other seeds may be waterborne for miles (Bey, 1990).
Soils	Alluvial deposits found on the low-elevation bottomlands of river and lake valleys (MacDougall and Loo, 1996).
Rooting habit	**Silver maple:** shallow, fibrous root system; **elm:** variable, depending on soil conditions, shallow on heavy, wet soils and deep on relatively dry, sandy soils.
Seedbed	**Silver maple:** does best on seedbeds of moist mineral soils with considerable organic matter; **elm:** best germination in light; can survive flooding for as long as 1 month; can become established on moist litter, moss, and decayed logs and stumps, but does best on disturbed mineral soil (Bey, 1990).

Management Recommendations

Option 1

Core: Avoid disturbance.

Buffer: Maintain a 170-m buffer to minimize edge effect and potential blowdown of the more shallow-rooted trees. Retain a crown closure of about 50% within the buffer by single-tree selection harvesting, but maintain all healthy elm, butternut, black ash, and black willow within the stand.

Underplant selected tree species in openings within the buffer if regeneration is insufficient.

As these tree species often grow within floodplains, they should not be harvested because they hold soil in place and are well adapted to surviving in flooded conditions. Few other tree species are suited to surviving in these zones.

Some of the rare plants associated with these areas may not re-establish if the soil is not held intact by tree roots. They may also require shaded conditions. Follow all guidelines under **"General Management Recommendations"** on page 10.

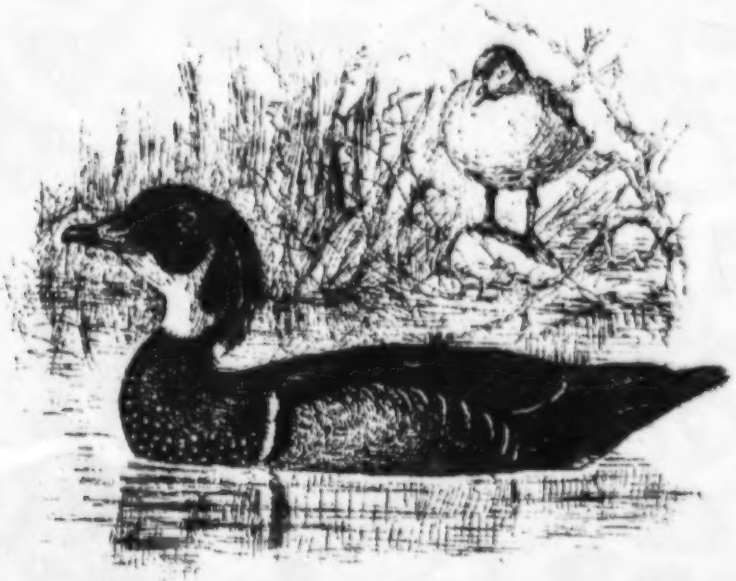
Option 2

Core: If harvesting is to be carried out, only 30% basal area removal is recommended by single-tree selection harvest, in compliance with New Brunswick Buffer Zone guidelines. Avoid harvesting black ash, butternut, basswood, and bur oak. These species are present in low numbers, so retention might increase their chances of regenerating.

Underplant target species if regeneration is insufficient.

Buffer: Follow guidelines for buffer as described in option 1 above.

Follow all guidelines under **"General Management Recommendations"** on page 10.



GLOSSARY

Age-class: a distinct group of trees or portion of the growing stock recognized on the basis of age.

Alluvial bottomland: eroded soil deposited by flowing water within the floodplains of rich valley bottoms.

Assemblage: a grouping of species particular to certain site conditions or habitats.

Biological diversity (biodiversity): the variety and abundance of species, their genetic make-up, and the communities, ecosystems, and landscapes in which they occur. It also refers to ecological structures, functions, and processes at all levels, from a rotting log in a woodlot to a coral reef in the ocean.

Canopy: the top layer in the forest.

Clearcutting: a term used to describe a timber harvest in which all of the trees are removed at one time. Clearcutting results in the establishment of a new, even-aged stand of trees which can be naturally or artificially created.

Connectivity: a measure of how well different areas (patches) of a landscape are connected to each other. For example, a checker board has good connectivity because all of the black squares are connected and all of the red squares are connected, allowing easy movement from one area of the board to another, by using one color.

Critical winter habitat: habitat that is required for a particular species to survive the winter. In New Brunswick, mature softwood forest stands are necessary for marten and deer to survive our winters.

Crown: the branches and leaves on the upper part of the tree trunk.

Degraded forest stand: a forest stand where much of the original biodiversity has been lost. For example, high-grading a mature sugar maple stand to remove all the best-formed trees, and leaving behind a young red maple, balsam fir stand with large patches of raspberry.

Early successional species: species of plants or animals that move into an area after a major disturbance, such as poplar on a burned area, but are often temporary inhabitants until late successional species move in. These species are well adapted to change, can often use a variety of habitats and tend to be more aggressive than late successional species.

Ecological integrity: minimal loss of natural biodiversity on natural, unmanaged, or managed ecosystems, which is maintained into the future.

Ecological land classification: a classification scheme used to delineate differing scales of landscape, or ecosystems, based on factors such as climate, landform, and vegetation.

Ecologically sensitive sites: sites that are less common than they used to be, or sites that contain rare species due to limited available habitat.

Ecoregion: an area of land characterized by a unique climate that is created by elevation and distance from oceans, which would have a cooling, higher moisture effect. These areas usually support distinctive plant communities and can be mapped.

Ecosystem management: management designed to maintain the interactions between all of the species in a given area and their non-living environment.

Ecosystem functions: the many and varied living and non-living processes that keep an ecosystem working, changing, and interactive (*e.g.*, nutrient cycling, when a tree takes up water and produces new wood from the nutrients; and decomposition, where the leaves fall from the tree and are turned back into soil by bacteria and other organisms).

Endangered species: any species that is in danger of extinction throughout all or a significant portion of its range.

Even-aged stand: a stand of trees in which most of the trees are about the same age. Even-aged stands result from disturbances occurring at one point in time, such as wildfires, a clearcut, a seed-tree cut, a shelterwood cut or stump sprouts.

Forest structures: all parts of the forest, including tree sizes, tree species, amount of deadwood, ground plant species, number of wild life trees, fungi, birds, mammals, and amphibians, *etc.*

Habitat: part of the environment that provides all the basic needs of a particular species, such as food, water, shelter, space, and air, without which the species cannot survive.

Interior forest species: species of plants or animals that require large, undisturbed areas of long-lived, shade-loving tree species and cannot compete with aggressive edge species. Forest interior birds, such as the Swainson's thrush, tend to require large tracts of forest habitat for nesting and foraging away from the predators often found along forest edges, such as Brown-headed cowbirds and raccoons.

Intermediate forest species: species that can tolerate light shade for regeneration, but can compete well in either light shade or full sun once established.

Intolerant forest species: short-lived, sun-loving plants that easily become established following major disturbance.

Landscape: a specific area of land, having no basic size or shape.

Late successional species: a species requiring habitat provided by long-lived, shade-loving plants that usually undergo small-scale disturbances over long time periods. They are not adapted to large-scale change and can be easily replaced by more aggressive, early successional species.

Natural forest: forest areas where most of the natural biodiversity has been maintained and has undergone limited human intervention.

Non-timber forest product: any product obtained from the forest that does not require the harvesting of trees, *e.g.*, maple syrup, medicinal herbs, edible mushrooms, *etc.*

Old-growth forest: a forest containing large, long-lived trees, large standing dead trees, numerous logs lying about the forest floor, and multiple canopies created by the crowns of trees of various ages.

Overstorey: the upper level of the forest created by the crowns of trees or shrubs.

Presettlement forest: forest condition prior to European settlement, characterized by certain species mixes, ages, and sizes of trees and plants.

Regeneration: the growth of seedlings that replaces a forest stand as the mature trees die or are harvested.

Release: when individual trees are exposed to increased light levels from the removal of another tree that may have been shading it; 'released' trees may grow faster.

Riparian zone: refers to the vegetation zone along a river, stream, lake or other wetland.

Stand: a group of trees that are similar in age structure and species mix, and occupy a specific area of land (*e.g.*, pine or maple stand). Stands are the basic management unit in silviculture.

Structural diversity: the diversity in a forest that provides a variety of forest habitats for plants and animals. These structures may include: dead and dying trees, both standing and on the ground; different crown heights; different tree species, such as hardwood and softwood; water; and a variety of soil types, *etc.*

Stump sprouts: new tree shoots growing from a stump.

Succession: the process of species replacing another group of species over time, such as when white spruce move into an old field and replace the grasses or alders growing there.

Suppression: when one plant species is shaded out by a more aggressive or physically larger plant species, the plant that is shaded out is said to be suppressed.

Tolerant species: a plant species that tolerates or requires shade to regenerate or reestablish itself.

Threatened species: any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Understorey: the lower canopy or shrub layer of the forest.

Uneven-aged stand: a stand in which intermingling trees differ markedly in age. The differences in age found in an uneven-aged stand may be greater than 10—20 years and usually form more than three distinct age classes.

Wild life: any species of fauna (animal life), or flora (plant life) living unrestrained or free-roaming and not domesticated.

Wild life travel corridors: travel routes connecting two areas of habitat and differing from the habitat on either side. Corridors are used by plants and animals to move around under cover, without having to leave the preferred habitat.

Windfirm: deep-rooted tree species that are not easily uprooted by wind.

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LITERATURE CITED

Bey, C.F. 1990. *Ulmus americana* L. - American Elm. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. 2, Hardwoods. USDA Forest Service, Agric. Handbook 654, pp. 801-807.

Blum, B.M. 1990. *Picea rubens* Sarg. - Red Spruce. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. I, Conifers. USDA Forest Service, Agric. Handbook 654, pp. 250-258.

Burns, R.M. and Honkala, B.H. 1990. Silvics of North America, Vols. I and 2. USDA Forest Service, Agricultural Handbook 654.

Clayden, S., McAlpine, D., and Guidry, C., 1984. *Rare and vulnerable species in New Brunswick.* Publications in Natural Science N°2, New Brunswick Museum, St. John, NB.

De Graaf, R., Yamasaki, M., Leak, W., and Lanier, J., 1992. *New England Wildlife: management of forested habitats.* USDA Forest Service, General Technical Report NE-144.

Erskine, A.J. 1992. *Atlas of Breeding Birds of the Maritime Provinces.* Nova Scotia Museum and Nimbus Publishing Company, Halifax, NS.

Forest Ecology Site Group.1995. *Post Harvest Vegetation Response - Analysis of New Brunswick 5th Year Survey Data.* Forest Management Branch, Department of Natural Resources and Energy. Unpublished report. 32 p.

Fundy Model Forest. 1997. *Conservation stewardship: An options guide for private woodlot owners within the Fundy Model Forest of southeastern New Brunswick.* Fundy Model Forest, RR#4, Alton Road, Sussex, NB.

Gabriel, W.J. 1990. *Acer saccharinum* L. - Silver Maple. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. 2, Hardwoods. USDA Forest Service, Agric. Handbook 654, pp. 70-77.

Godman, R.M., and Lancaster, K. 1990. *Tsuga canadensis* - Eastern Hemlock. *In* R.M. Burns and B.H. Honkala. (*Tech. Coords.*) Sivlics of North America, Vol. I, Conifers. USDA Forest Service, Agric. Handbook 654, pp. 604-612.

Godman, R.M., Yawney, H.W., and Tubbs, C.H. 1990. *Acer saccharum* Marsh. - Sugar Maple. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. 2, Hardwoods. USDA Forest Service, Agric. Handbook 654, pp. 78-91.

Hinds, H. 1986. *Flora of New Brunswick.* Primrose Press, Fredericton, NB.

Hunter, M.L. Jr. 1990. *Wildlife, Forests, and Forestry: Principles of Managing Forests for Biological Diversity.* Prentice Hall, Inc., Englewood Cliffs, New Jersey, 07632. ISBN 0-13-959479-5.

Johnson, W.C., and Adkisson, C.S. 1986. Airlifting the Oaks. *In* Natural History, October, 1986.

Johnston, W.F. 1990. *Thuja occidentalis* L. - Northern white-cedar. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. 1, Conifers. USDA Forest Service, Agric. Hand book 654, pp. 580-588.

Leak, W.B., D.S. Soloman, and DeBald, P.S. 1987. *Silvicultural Guide for Northern Hardwood Types in the Northeast* (revised). USDA Forest Service, Research Paper NE-603. Broomall, P.A.: USDA, Forest Service, Northeastern Experimental Station.

Livingstone, D. 1968. Some interstadial and post-glacial pollen diagrams from Eastern Canada. *Ecol. Monogr.* 38: 87-126.

Lutz, S.G. 1997. *Pre-European Settlement and Present Forest Composition in Kings County, New Brunswick, Canada.* Graduate Thesis, Faculty of Forestry and Environmental Studies, University of New Brunswick, Fredericton, NB.

MacDougall, A., and Loo, J. 1996. *Fine-Scale Community Types of the Fundy Model Forest in Southeastern New Brunswick.* Canadian Forest Service - Atlantic Forestry Center, Natural Resources Canada, Information Report M-X-198E.

Maine Natural Heritage Program. 1991. *Natural Landscapes of Maine: A Classification of Ecosystems and Natural Communities.* Office of Comprehensive Planning, Augusta, Me.

Matlack, G.R. 1994. Vegetation dynamics of the forest edge - trends in space and successional time. *Journal of Ecology* 82: 113-123.

Metzger, F.T. 1990. *Ostrya virginiana* (Mill.) K. Koch - Eastern Hophornbeam. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. 2, Hardwoods. USDA Forest Service, Agric. Handbook 654, pp. 490-495.

Noss, R. 1987. Protecting Natural Areas in Fragmented Landscapes. *Natural Areas Journal* 7(1):

Perley, M.H. 1847. Report on the Forest Trees of New Brunswick. *Simmonds Colonial Magazine* XI (42): June.

Perley, M.H. 1863. *80 years Progress of North America.* Microfiche, pp. 561-574,

Power, R.G., and Matson, B.E. 1995. *Ecological Land Classification of Southeastern New Brunswick.* New Brunswick Department of Natural Resources, PO Box 150, Hampton, NB.

Rink, G. 1990. *Juglans cinerea* L. - Butternut. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. 2, Hardwoods. USDA Forest Service, Agric. Handbook 654, pp. 386-390.

Sander, I.L. 1990. *Quercus rubra* L. - Red Oak. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. 2, Hardwoods. USDA Forest Service, Agric. Handbook 654, pp. 727-733.

Schlesinger, R.C. 1990. *Fraxinus americana* L. - White Ash. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. 2, Hardwoods. USDA Forest Service, Agric. Handbook 654, pp. 333-338.

Seymour, R.S. 1992. The red spruce-balsam fir forest of Maine: Evolution of silvicultural practice in response to stand development patterns and disturbances. *In* M.J. Kelty, B.C. Larson, and C.D. Oliver (*Eds*), *The ecology and silviculture of mixed species forests.* Kluwer Academic Publ., pp. 217-244.

Simberloff, D.1993. How forest fragmentation hurts species and what to do about it. *In* WW Covington and LF DeBano (*Technical Advisors*). Proceedings of Sustainable Ecological Systems: Implementing an Ecological Approach to Land Management Conference, July 12—15, 1993, Flagstaff, Arizona. General Technical Report RM-247, USDA.

Tubbs, C.H. and Houston, D.R. 1990. *Fagus grandifolia* Ehrh. - American Beech. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. 2, Hardwoods. USDA Forest Service, Agric. Handbook 654, pp. 325-331.

Villard, M. 1997. Landscape ecology of forest birds: does the scenery matter? *In* Proceedings of an Ecological Landscape Management Workshop, Fredericton, N.B, October 1997. Canadian Woodlands Forum, Canadian Pulp and Paper Association. pp 81-85.

Wendel, G.W., and Clay Smith, H. 1990. *Pinus strobus* L. - Eastern White Pine. *In* R.M. Burns and B.H Honkala. (*Tech. Coords.*) Silvics of North America, Vol. I, Conifers. USDA Forest Service, Agric. Handbook 654, pp. 476-486.

Woodley, S., and Forbes, G. 1997. *Forest management guidelines to protect native biodiversity in the Fundy Model Forest.* Greater Fundy Ecosystem Research Group Report. New Brunswick Cooperative Fish and Wildlife Research Unit, University of New Brunswick, Fredericton, NB.

Zelazny, V., and Veen, H. 1997. *Acadian forest, past and present. In* Proceedings of an Ecological Landscape Management Workshop, Fredericton, NB, October 1997. Canadian Woodlands Forum, Canadian Pulp and Paper Association. pp.9-13.

APPENDIX
CONSERVATION STEWARDSHIP IN THE FUNDY MODEL FOREST: LANDOWNER OPTIONS[2]

One of the biggest concerns landowners have regarding stewardship are the restrictions involved in obtaining an agreement. However, private stewardship programs put landowners' concerns first, and consider protection from their point of view. As a result, stewardship agreements may involve little or no changes to land use, or may include an extensive management plan outlining how the owner can maintain, or even expand, the natural features that make the property special.

For interested landowners, we offer the following options:

1. **Verbal Agreements***

   This option, often referred to as a "handshake" agreement, generally involves a commitment from the landowner to maintain the habitat to the "best of their ability" and to notify the organization of any threats to the area or of any intended land use or ownership change.

2. **Written Agreements***

   Written stewardship agreements are basically a signed version of a verbal agreement and do not require additional landowner commitment.

* **If a landowner is interested in entering into a non-binding verbal or written agreement to protect their property they can contact one of the following non-governmental organizations:**

The Nature Trust of New Brunswick Inc.
P.O. Box 603 Station A,
Fredericton, N.B.
E3B 5A6
Phone: (506) 457-2398
Fax: (506) 450-2137

The Nature Conservancy of Canada
Atlantic Regional Office
924 Prospect St., Suite 2
Fredericton, N.B.
E3B 2T9
Phone:(506) 450-6010
Fax: (506) 450-6013

New Brunswick Community Land Trust
180 St. John Street
Fredericton, N.B.
E3B 4A9
Phone: (506) 459-4829

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[2] Reprinted from A. MacDougall and J. Foley. 1999. "Conservation Stewardship", a guide produced for the Fundy Model Forest.

3. Management Agreements

These are legal contracts in which land management assistance is provided. In stewardship programs, the function of this type of agreement is to encourage a landowner not only to restrict certain land-use activities but also to apply a management plan for the property. The management plan is prepared by the sponsoring agency which will also provide technical expertise. The plan is a detailed outline of the use and activities that can occur within a recognized privately owned natural area. The type of management plan that is developed depends on the sensitivity of the site's special features, and the current and anticipated economic needs of the owner. Some sites can tolerate limited timber harvest throughout. Some have areas where any type of activity would be detrimental. Again, the idea is not to freeze all land-use practices, but simply to ensure that the valued ecological features are maintained.

We suggest two alternatives for owners seeking to develop an ecologically sensitive management program. The first involves consultation with the forestry extension officer from NBDNRE in Hampton and the second involves working with SNB's Working Woodlot program. These options seek to develop both short- and long-term plans for managing the land in a way that addresses both environmental and economical concerns. The following are brief descriptions of options. If you find that one of the options suits your needs, contact the organization for more information.

4. Property Lease

Local conservation agencies may be willing to lease a property that encompasses all or part of an ecologically significant area. This type of protection ensures conservation stewardship on the part of the tenant. Leasing agreements set out the terms by which the landowner grants the tenant the right to enter and manage the property. Landowners reluctant to part with their land are able to retain the land and have it protected for a number of years.

5. Property Sale

Some landowners will, at some time or another, consider selling their property. If there is interest in selling to a conservation agency, several options are available.

a. Fee Simple Sale - All the rights that are attached to the property are sold for the current market value.
b. Sale with Reserved Life Estate - Even though the land has been sold to a conservation agency, the owner may continue to reside on the property for the duration of his/her life.
c. Right of First Refusal - Perhaps the landowner wants to sell a property to a conservation agency, however the agency is unable to purchase it immediately. The landowner could then sign a right of first refusal. This agreement does not obligate the agency to purchase the land; however, it does guarantee the conservation agency the opportunity to do so. If another party offers to buy the land, the landowner is legally obliged to allow the conservation agency the chance to match the offer.

d. Restricted Covenant - In some provinces, sales can be made with restrictive covenants added to the deed that limit future owners' rights to alter the natural features on the land. Legislation in New Brunswick to allow such land restrictions is presently being considered by the NBDNRE.

6. Land Donation

Donation of land to a conservation agency is the simplest way to protect your land. By transferring the title to the agency, not only is the landowner providing long-term protection to the land but will also receive tax benefits in the form of income tax deductions. The amended Federal Income Tax Act now provides a landowner with a tax credit of up to 100% of the donor's net income for donation of ecologically sensitive lands to qualified organizations. This credit can be applied against your income tax in the year in which the donation is made. It can also be used for up to 5 carry-forward years, but must be limited to the federal component of your income tax.

With respect to land donations several, options exist:

a. Outright Donation - Full title and ownership to the land is transferred to the conservation agency. This offers the maximum tax advantages because the landowner may take a charitable gift deduction based on the full market value of the property.

b. Donation by Devise - A gift of land through a will is a donation by devise. The landowner retains full use and control over the property while he/she is alive and ensures its protection after his/her death. Income tax benefits are not possible during the lifetime of the donor and the property tax must be paid until the property is transferred to the conservation organization.

c. Donation with Reserved Life Estate- Although the land has been donated to a conservation agency, the owner, and/or designated immediate family, may continue to live on the property for the rest of their lives and use it, providing they do not damage the natural area. The tax advantages are less than with an outright donation but greater than a donation by devise.

If your property qualifies and you wish to participate in this program, please contact one of the organizations listed below.

The Nature Trust of New Brunswick
P.O.Box 603, Station A,
Fredericton, N.B., E3B-5A6
Phone: (506) 457-2398
Fax: (506) 450-2137

The Nature Conservancy of Canada
85 Country Squire Lane
Charters Settlement, N.B. E3C-1W5
Phone: (506) 450-6010
Fax: (506) 450-6013